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THE BATTLE OF TRAFALGAR.

THE eightieth anniversary of the battle has arrived, and there is only one surviving officer, Lieut.-Colonel James Fynmore, of the Marines. He is ninety-two years of age—the portrait we publish (from a photograph) was only taken the other day—yet he is in excellent health, and is possessed of wonderful sight. He still amuses himself with sketching and painting, for which his father also had a strong taste, and he has lately finished a water color drawing of one vessel towing another two days after the battle of Trafalgar. The picture, however, which we have reproduced was drawn by Lieut.-Colonel Fynmore in 1875, when he was eighty-two. It represents H. M.'s frigate Euryalus, Admiral Collingwood, collecting his fleet after the battle of Trafalgar, October 21, 1805. In the foreground appears H.

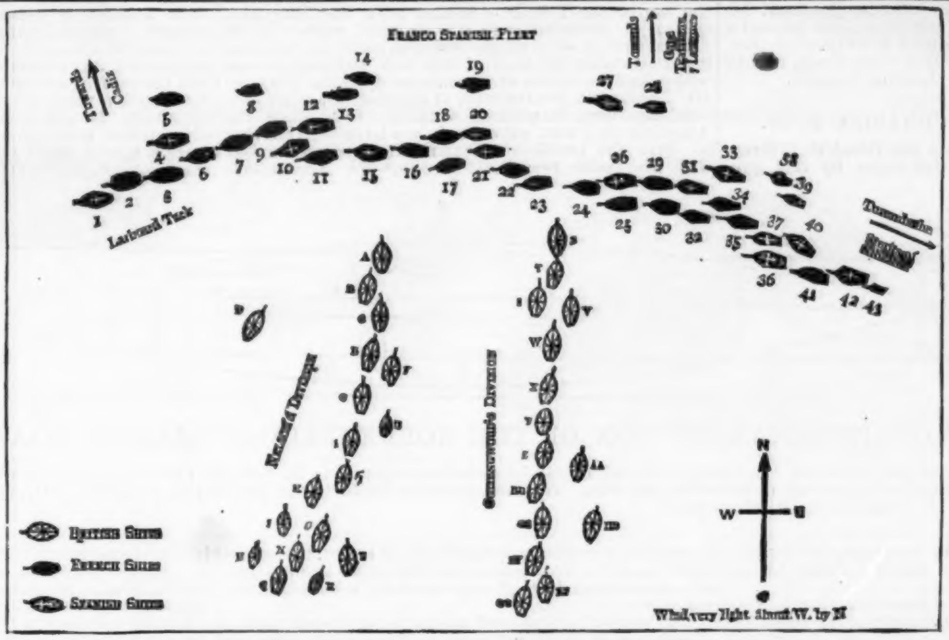
As the morning mist rolled away on the 21st of October, 1805, the enemy's fleet was discovered, drawn up in the shape of a crescent. In the British fleet was heard the roll of drum beating to quarters, as ship after ship took up its position. The whole fleet was divided into two columns, respectively led by Nelson and Collingwood. About noon the engagement commenced. Collingwood first came into action, and Nelson broke the enemy's line, pouring in broadside after broadside, thus throwing all into confusion. Both fleets were now enveloped in smoke, and in some parts of the engagement vessels came into such close contact that three-deckers fired over three-deckers, while Spanish and French fired into one another. In the thickest of the fight Nelson fell, the command devolving on Collingwood. About four o'clock the enemy begun to draw off, and all was over. As evening set in, a terrific storm arose, which so scattered the fleets during the night that many of the enemy's vessels foundered, the majority of which had prize crews on board. Not one of the English fleet was lost. On the morning of the 22d the enemy was drawn up as if intending to renew the fight, but subsequently dispersed. Most of their ships were captured or destroyed. Thus ended the glorious day that shook the power of Napoleon.

The Franco-Spanish fleet consisted of 18 French and 15 Spanish line of battle ships. The ships were mixed, without any apparent regard to order of national squadron, so much so that, instead of being straight, the line was curved or crescent-like. The diagram will show the position of the two fleets previous to the commencement of the battle at about 11.30 A. M., as recorded by naval and civil historians, and from my observation as a midshipman of the Africa.

French and Spanish struck 19 sail of the line, with three flag officers: Vice-Admiral Villeneuve, the Commander in Chief, Don Ignacio Maria d'Alava, and Spanish Rear-Admiral Don Baltasar Hidalgo Cisneros. There were 4,000 troops embarked, under General Contamin, who was taken with Admiral Villeneuve. English loss estimated at 1,587 of all ranks. The enemy, as stated, nearly 16,000. The battle ceased about 4.30 P.M. The numbers after each ship denote its guns. The English fleet consisted of 27 sail of the line, 4 frigates, 1 schooner, 1 cutter.

JAMES FYNMORE, Lieut.-Col. R. M.

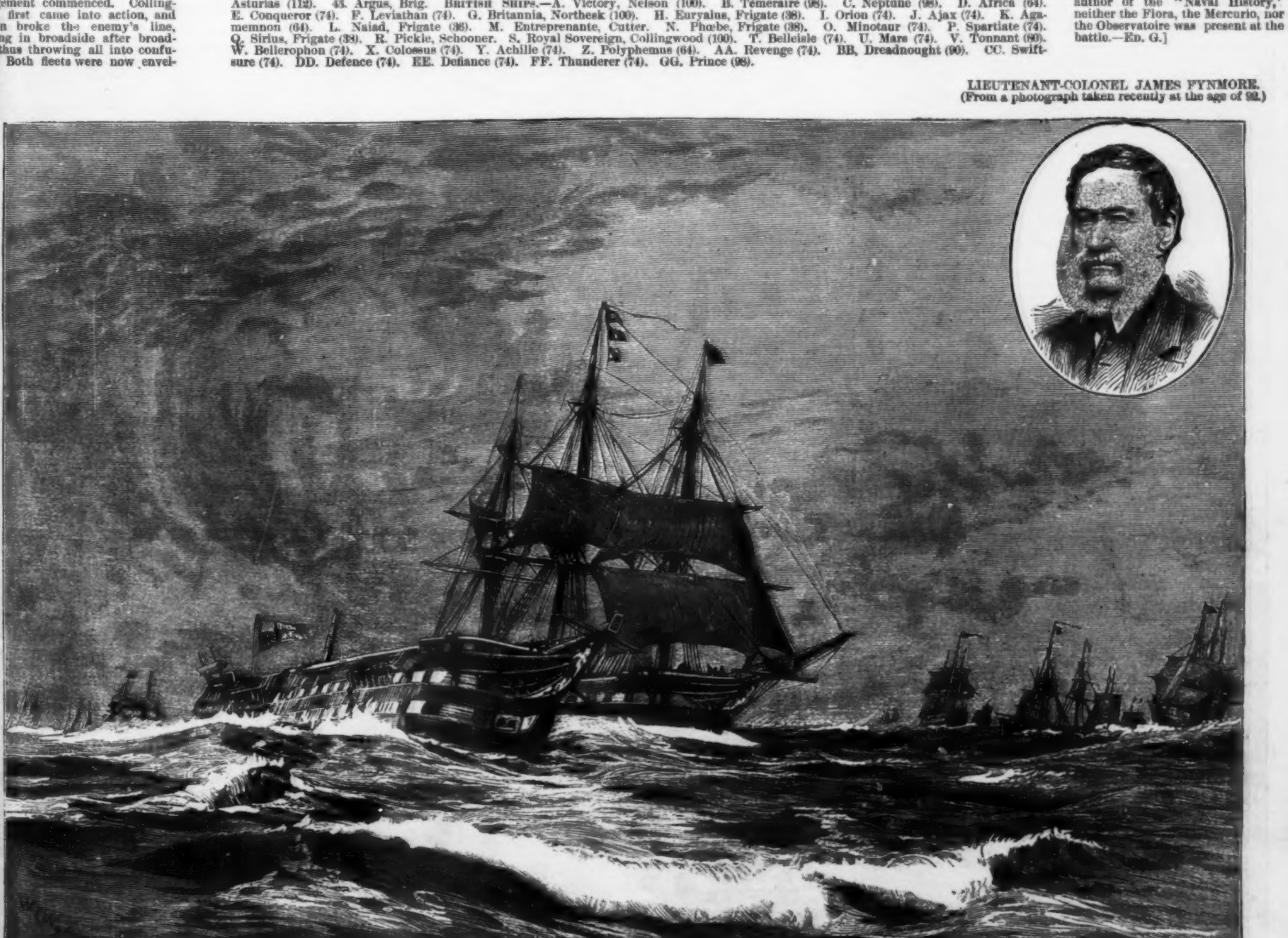
[According to James, the accurate author of the "Naval History," neither the Flora, the Mercurio, nor the Observatoire was present at the battle.—ED. G.]



PLAN OF THE BATTLE OF TRAFALGAR, OCTOBER 21, 1805.

FRENCH AND SPANISH SHIPS.—1. Neptuno (74). 2. Scipion (74). 3. Intrépide (74). 4. Rayo (100). 5. Cornélie, Frigate (40). 6. Formidable (80). 7. Duguay-Trouin (74). 8. Rhin. Frigate (40). 9. Mont Blanc (74). 10. San Francisco d'Assisi (74). 11. Héros (74). 12. San Augustin (74). 13. Furet, Brig (18). 14. L'Observatoire, Brig (16). 15. Santissima Trinidad (130). 16. Bucentaure (80). 17. Redoutable (74). 18. Neptune (80). 19. Hortense, Frigate (40). 20. San Leandro (64). 21. San Justo (74). 22. Indomptable (80). 23. Sta Anna (112). 24. Fougueux (74). 25. Pluton (74). 26. Monarca (74). 27. Flora, Frigate (44). 28. Mercurio, Frigate (40). 29. Algesiras (74). 30. Aigle (74). 31. Bahama (74). 32. Swiftsure (74). 33. Montanez (74). 34. Argonaute (74). 35. Berwick (74). 36. San Ildefonso (74). 37. St. Juan Nepomuceno (74). 38. Hermione, Frigate (40). 39. Thémis, Frigate (40). 40. Argonauta (80). 41. Achille (74). 42. Principe de Asturias (112). 43. Argus, Brig. BRITISH SHIPS.—A. Victory, Nelson (100). B. Téméraire (98). C. Neptune (98). D. Africa (64). E. Conqueror (74). F. Leviathan (74). G. Britannia, Northesk (100). H. Euryalus, Frigate (38). I. Orion (74). J. Ajax (74). K. Agamemnon (64). L. Naiad, Frigate (36). M. Entreprenante, Cutter. N. Phœbe, Frigate (38). O. Minotaur (74). P. Spartiate (74). Q. Sirius, Frigate (38). R. Pickle, Schooner. S. Royal Sovereign, Collingwood (100). T. Belleisle (74). U. Mars (74). V. Tonnant (80). W. Bellerophon (74). X. Colossus (74). Y. Achille (74). Z. Polyphemus (64). AA. Revenge (74). BB. Dreadnought (90). CC. Swiftsure (74). DD. Defence (74). EE. Defiance (74). FF. Thunderer (74). GG. Prince (98).

LIEUTENANT-COLONEL JAMES FYNMORE.
(From a photograph taken recently at the age of 92.)



THE EIGHTIETH ANNIVERSARY OF THE BATTLE OF TRAFALGAR, FOUGHT OCTOBER 21, 1805.—ADMIRAL COLLINGWOOD COLLECTING HIS FLEET THE MORNING AFTER THE BATTLE. (From a water-color drawing by Lieutenant-Colonel James Fynmore, R.M.L.I., sole surviving officer of the battle, in which he took part as a midshipman.)

M.'s Africa, 64 guns, dismasted and in distress. The Africa, on board of which Colonel Fynmore's father was a Captain of Marines, and himself a midshipman, lost more in killed and wounded than any other vessel in the fleet; she was commanded by "Fighting Digby," as he was called, and was simultaneously engaged with the Santissima Trinidad and two French liners. During the night after the battle a terrible gale came on, and no wonder the next day the Africa was in a sad plight.

Lieut.-Colonel Fynmore comes of a good old Berkshire family, famous for length of life. His father's sister died at the age of 104. Both his father and his grandfather served in the Marines. His son, Mr. W. R. Fynmore, retired naval storekeeper, to whom we are indebted for these particulars, is fifty-five years of age, and the last of the family in England.

Lieut.-Colonel Fynmore entered the Royal Navy in 1803, and the Marines in 1808. He was at the bombardment of Algiers in 1816. At that engagement his "tubes" were tried for the first time, and proved a great success. From that day they have been universally used. He served twenty-five years at sea, twenty on shore, and retired in 1848.—*London Graphic.*

THE NORDENFELT SUBMARINE BOAT.

The annexed cut, taken from the *Illustrite Zeitung*, represents some of the trial trips made by this submarine boat at Copenhagen, accompanied by the Danish man-of-war Diana, the English yacht Osborn, and a Danish gun-boat.

The vessel is provided with a glass dome for the captain, with propeller screws for propelling the vessel forward, and raising and lowering it in the water, and with suitable steering devices and mechanism for keeping it horizontal. Steam is generated by means of anthracite coal, so as to produce as little smoke as possible, and when the boat sinks the fires are sealed, and the reserve steam is used, which is kept at high pressure in suitable tanks. The greatest depth attained was 16 ft.; and, by properly changing and regulating the revolutions of the vertical screw, the boat can be kept within one foot of the desired distance under water at all times. The greatest distance traversed under water was 16 miles; the greatest speed attained on the surface was about 8 knots, and under water the speed was reduced to about 4 knots for the sake of safety. The greatest distance traversed by the boat was from Stockholm to Gothenburg, and, notwithstanding the fact that the weather was unfavorable and the sea very rough, the vessel behaved perfectly.

Of what value this vessel will be in marine warfare cannot be determined until more experiments have been made. If these experiments prove successful, this vessel will not only be dangerous to the monstrous ironclads, but will be a most effective means of attacking forts and other coast defenses.

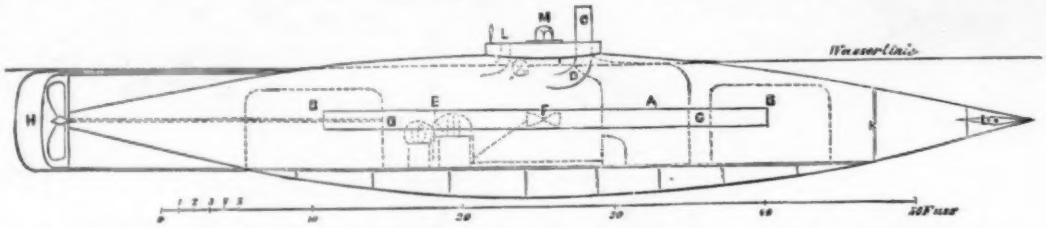
THE NORDENFELT SUBMARINE BOAT.

In September last, just before leaving Denmark for the south, the Prince of Wales, with the King and Queen of Denmark and the Czarina, witnessed off Landskrona, a town on the Swedish coast, an interesting and successful trial of the new submarine boat which had been built at Stockholm upon the plans of Mr. Nordenfelt, the inventor of the machine gun so extensively used in modern warfare. Ever since the American civil war, naval engineers have been striving to solve the problem of submarine navigation, but until now with very little success. Mr. Nordenfelt's invention, however, appears to fulfill the numerous requirements for overcoming the difficulties and dangers of maintaining, driving, and directing a boat beneath the water.

The boat is built of steel, and is cigar-shaped, with a glass conning tower in the center, from which the commander can keep a lookout. This dome is protected by a strong iron cover. There are three engines, one to work the screw in the stern, which propels the vessel, and two to work the propellers on either side, which, when set in motion, compel the boat to sink, and maintain her at a certain depth beneath the surface. When it is wished to sink the boat, enough sea water is taken in to reduce the buoyancy to 1 cwt., and this suffices to keep the tower just above the surface. The side propellers then being set in motion, the vessel can be sunk to a required depth, there being an automatic arrangement by which the engines are stopped directly that depth is exceeded. An automatic horizontal steering gear also prevents the boat from going down or up head foremost, an even keel being preserved throughout all the maneuvers. Should a breakdown of the engine occur, the boat from its own buoyancy at once rises to the surface.

The motive power is steam, and as long as the vessel is above water the fires can be stoked, the smoke being driven through two channels, which pass partly round the hull and point aft. When, however, the boat sinks, the fires have to be sealed, and reserve steam is used, which is kept at high pressure in two tanks. With this the boat has been driven for five hours at a speed of three miles an hour. Her speed on the surface is eight knots. The crew number three, and during their submarine existence have to subsist on the amount of air which they take with them in the hull, in which four men have subsisted for six hours without any special inconvenience. The boat is 64 feet long, and the central diameter is 9 feet. The enormous utility of such a vessel as this in naval warfare is at once apparent. Moving without the slightest apparent sign of existence, she can launch torpedoes against hostile vessels, enter a harbor unperceived, and render useless the most complicated system of submarine mines. The trial at Landskrona was witnessed by officers representing every European power. Admiral Arthur and Major-General Sir Andrew Clarke were among those representing the English services.

We are indebted to the *Illustrated London News* and London *Graphic* for our sketches.

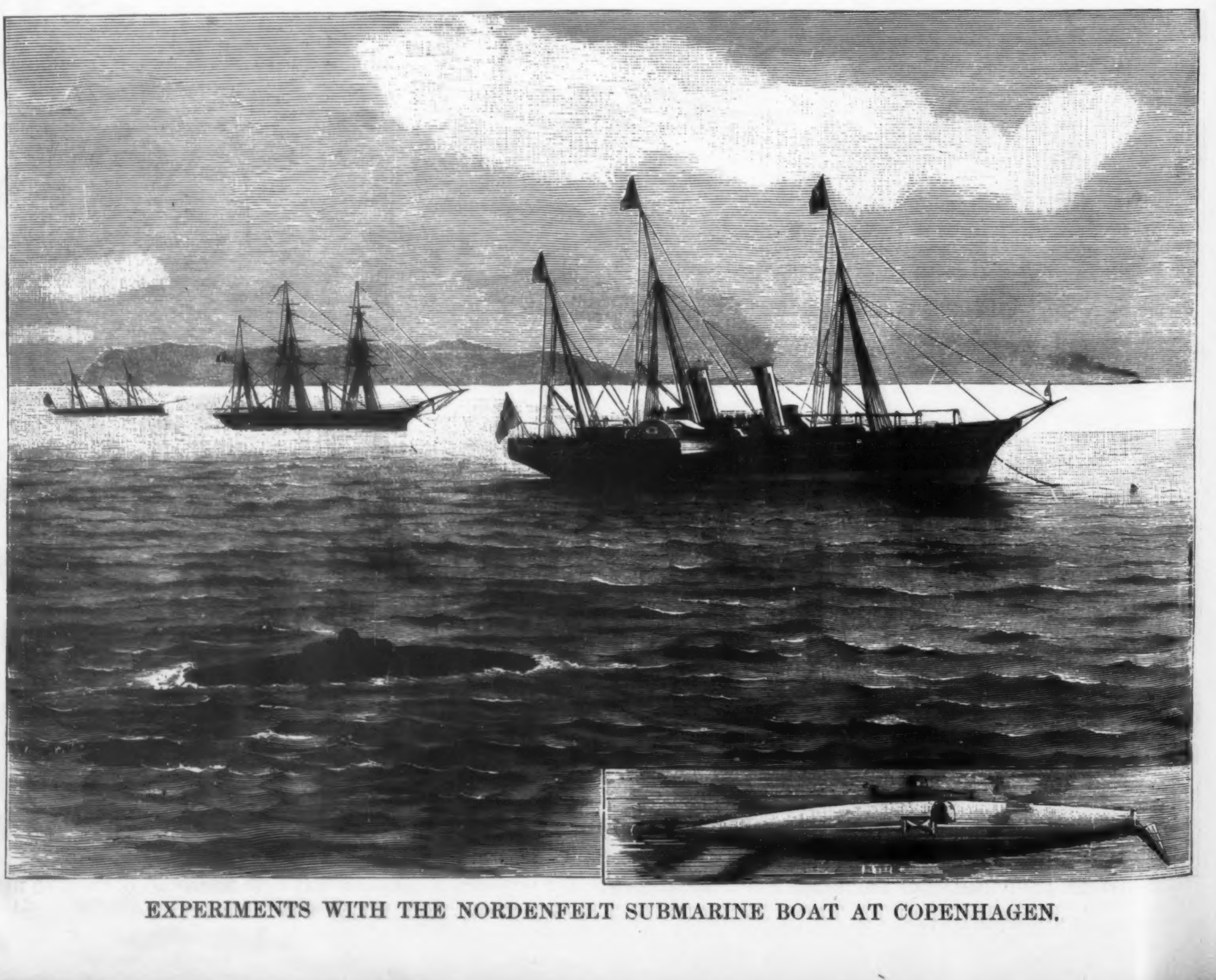


LONGITUDINAL SECTION OF THE NORDENFELT SUBMARINE BOAT.

A. Steam boiler. B. Reservoir for hot water. C. Smokestack, which can be sealed hermetically. D. Exhaust pipes for the steam when the smokestack is sealed. E. Engines. F. Side propeller for raising and lowering the boat. G. Compartments for the protection of side propellers. H. Vertical rudder. I. Horizontal rudder. K. Bulkhead. L. Ventilator. M. Glass dome.

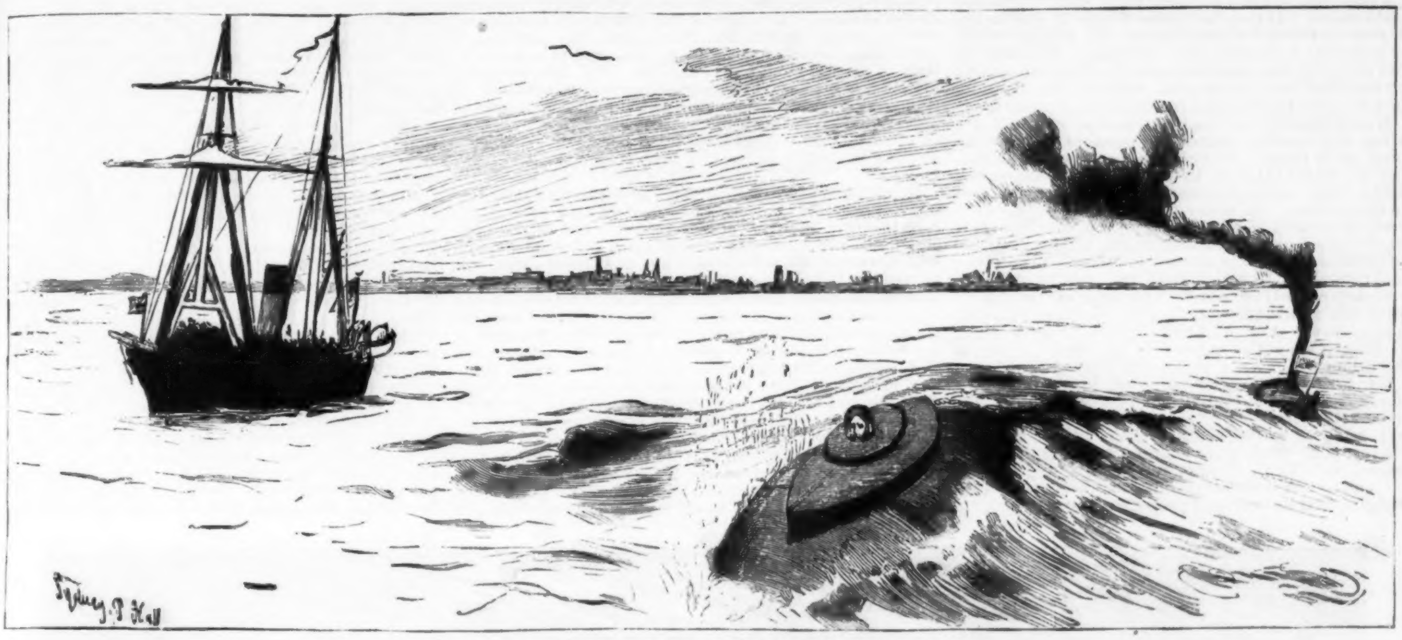
THE NORDENFELT SUBMARINE BOAT.

The interest excited by the recent trials of the Nordenfelt submarine boat is sufficiently shown by the presence at Landskrona of thirty-nine officers, representing every European power, together with Brazil and Japan. Such a boat, if successful, will exercise a power-



EXPERIMENTS WITH THE NORDENFELT SUBMARINE BOAT AT COPENHAGEN.

ful influence both on naval warfare and on coast defense. Its possible uses are manifold, its moral effects unquestionable. Against its operations no system of defense at present suggested seems adequate. The introduction of fast torpedo boats has supplied a new factor in warfare, and, *pace* Hobart Pasha, their influence will some day make itself powerfully felt. But the exceptionally dangerous antagonist. If the problem of producing such a boat can be solved, the largest ship would be secure only when in rapid motion, no port could be satisfactorily defended, and no system of submarine mines could be regarded as safe. Mr. Nordenfelt has addressed himself to the solution with a measure of success which will be discussed later.

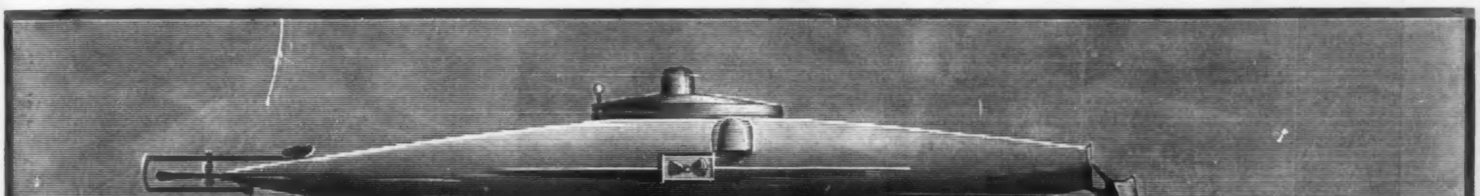


THE NORDENFELT SUBMARINE BOAT.

torpedo boat has been met actively by the machine gun, capable of delivering an extremely rapid fire of small shell at ranges far beyond the useful limit of the Whitehead, and passively by the steel wire netting with which it is proposed to surround ships. Again, the torpedo boat can be met and fought on the sea by similar boats, faster, better handled, or better armed. On the other hand, a boat which can maintain a fair speed under water for several hours, which need only rise to the surface for brief periods, and can sink at will if discovered, which can lie *perdu* and direct a steered torpedo, or run up to close quarters and fire the Whitehead at ten feet below the surface, is undoubtedly an

It is no new problem. Submarine boats were employed in the American war, where some successes were claimed for them; and considering the enormous advantages to be obtained, it is not surprising that at least one European power has devoted both time and money to experiment. But there has been a natural tendency to preserve secrecy on the subject—since to create the vague suspicion of the possession of a submarine boat would be a more desirable object than to proclaim the existence of one with known imperfections and limitations. Besides, the past record of the performances of these boats has not been free from disaster. Several have sunk with their crews to rise no more; others have remained fixed and helpless at the bottom for long periods, to be saved only by exceptional coolness and exertion on the part of the crews. It would be clearly unwise to create an antecedent impression of the exceptional danger involved in their service at a time when such danger might be due chiefly to structure, imperfection, and want of knowledge. For the problem is no easy one, when its conditions come to be realized. Power to sink and rise rapidly at will, fair speed under water, horizontal and vertical steering power under full control, endurance of motive force, and air supply for the crew, are only some of the many requirements on the fulfillment of which success is dependent.

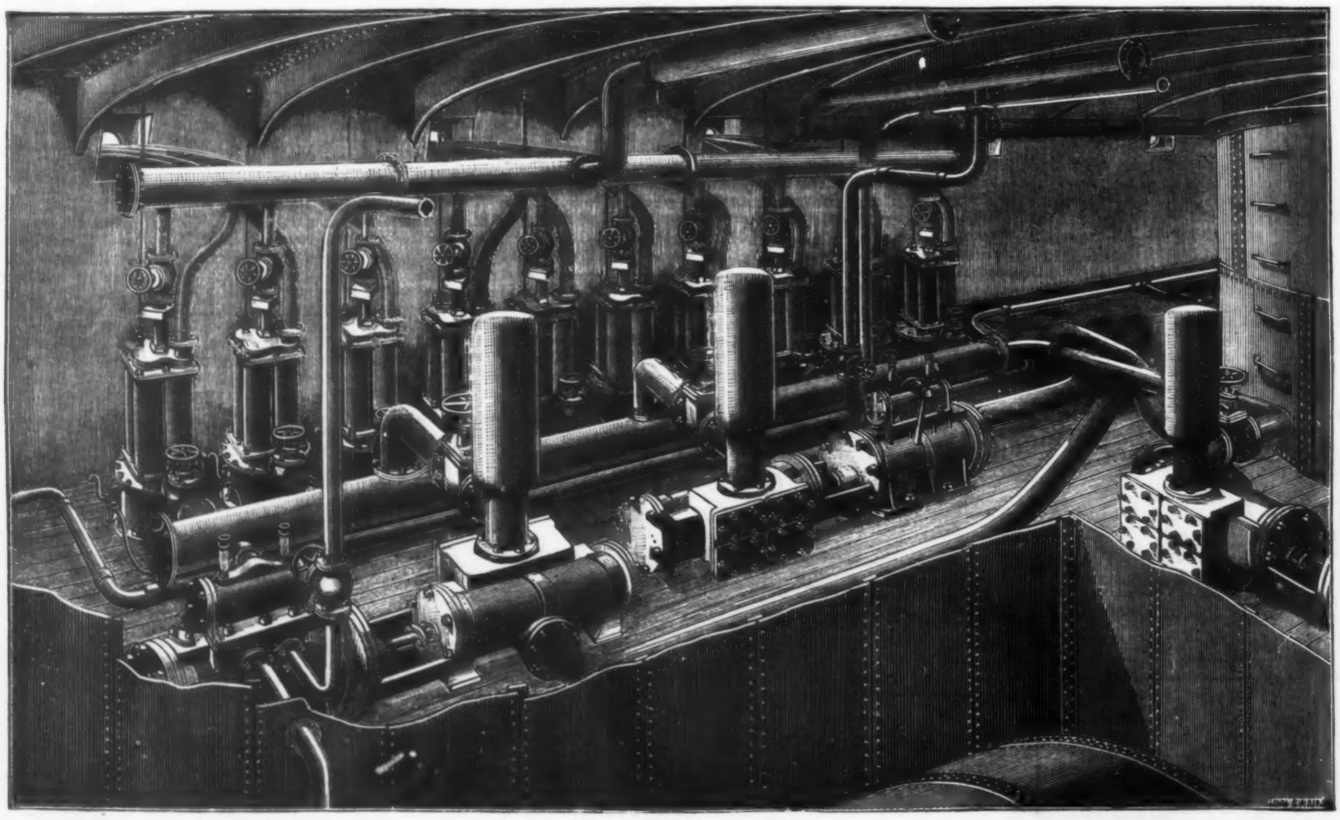
The Nordenfelt boat, the first of its class, was built at Stockholm about two years ago. The boat is cigar-shaped, with a coffin-like projection on the top amidships, formed by vertical combings supporting a glass dome, or conning tower, 1 ft. high, which enables the commander to see his way. The dome, with its iron protecting cover, stands on a horizontal lid, which can



THE RECENT EXPERIMENTS WITH THE NORDENFELT SUBMARINE BOAT AT LANDSKRONA, DENMARK.

1. The boat under water, the end removed for launching a torpedo. 2. On the trial trip from Landskrona to Helsingberg. 3. Mr. Nordenfelt, the inventor. 4. Captain Garret. 5. Interior of the boat: Mr. Nordenfelt explaining details to foreign delegates. 6. Towing the boat out of harbor. 7. View of Landskrona.

be swung aside to allow the crew of three men to get in or out without difficulty. The length of the hull is 61 ft., and the central diameter 9 ft. It is built of Swedish mild steel plates $\frac{5}{8}$ in. thick at the center, tapered to $\frac{3}{8}$ in. at the ends, supported on angle-iron framing, 3 in. by 3 in. by $\frac{3}{8}$ in. The arrangements for sinking the boat are of a special nature, for which the inventor claims important advantages. Practically, such a boat can be sunk in three ways, singly, or taken in combination. It may be forced down by power applied from within, weighted down by taking in sea water sufficient to destroy the buoyancy, or it may be steered down by the application of its ordinary motive power modified by a horizontal rudder. Mr. Nordenfelt has adopted the former arrangement, placing sponsons on each side of the boat amidships, in which are wells for the vertical propellers capable of working the boat up or down. In order to prepare for action, enough sea water is taken in to reduce the buoyancy to 1 cwt., which suffices to keep the conning tower well above the surface. In order to sink the boat farther, the vertical propellers are set in motion, and, by their action, it is held at the required depth. Thus, to come to the surface again, it is merely necessary to stop the vertical propellers, in which case the reserve of buoyancy at once comes into play. This principle is rightly regarded as important, even if not essential, in a safe submarine boat. A breakdown in the engines does not entail danger, since the reserve of buoyancy is never lost for a moment. As a still further safeguard, however, Mr. Nordenfelt has provided an automatic check on the downward motion. A lever, with a weight which can be adjusted so as to counterbalance any desired head of water, is connected with a throttle valve supplying steam to the engine working the vertical propellers. Thus, directly the desired depth is exceeded, the increased head of outside water overcomes the weight, and the vertical propellers are stopped.



SURFACE CONDENSERS OF THE S.S. CALABRIA.

The motive power is steam alone, generated in a boiler of ordinary marine type with a forced draught. So long as the boat runs on the surface, this boiler can be stoked and a constant head of steam maintained. The smoke is driven out through two channels which pass partly round the hull and point aft. For submarine work, no stoking is, of course, possible, and the firebox has to be sealed. It is, therefore, necessary to store the requisite power beforehand, and this is done by heating the water in two tanks placed fore and aft, and connected by circulating tubes with the boiler, till a pressure of about 150 lb. per square inch is attained. With about this initial pressure, it is stated that the boat has been driven for sixteen miles at a speed of three knots. The greatest surface speed attained is a little over eight knots, and the boat has been run for one hundred and fifty miles without recoaling. There are three sets of engines, one of which drives the propeller, an ordinary four-bladed screw 5 ft. in diameter, with a pitch of 7 ft. 6 in. The other engines drive the blower and the horizontal propellers respectively.

One of the principal difficulties of submarine navigation is to preserve an even keel when under water. Should a boat turn downward when in motion below the surface, it might easily strike the bottom or reach a depth at which it must collapse before its course could be arrested. On the other hand, if the bow took an upward turn under the same circumstances, the boat would rapidly come to the surface and be exposed to view and to projectiles. It is evidently, therefore, of the utmost importance to provide ample steering power in a vertical direction. In the Nordenfelt boat, two horizontal rudders are placed one on each side near the bows, and are acted upon by a pendulum inside the hull. This pendulum coming into play the instant the boat takes a cant in either direction, actuates the horizontal rudders and causes her immediately to return to an even keel. By this means it is claimed that the boat is automatically kept with her axis horizontal, while, since the bow rudders are entirely beyond the control of the crew, there is no danger of accident due to neglect or loss of nerve. In the event of a breakdown of the above arrangement, it is necessary at once to stop the boat and let her return to the surface. No compressed air is carried, and the crew depend, therefore, for existence on the amount of air sealed up in the hull. With this amount of air only, four men have remained for a period of six hours without any especial inconvenience. The above are the main features of the invention which Mr. Nordenfelt has just made public, and which has received the careful consideration of experts of many nations. In a subsequent article it is proposed to discuss the results obtained in the recent experiments as well as the measure of promise those results afford.—*London Times.*

SURFACE CONDENSATION.

NUMEROUS experiments have, at different times during the past thirty years, been made with a view to determine the quantity of heat which could be conducted by the surface of different metals. The experiments, which were made with steam, the heat from which was transmitted by a metallic medium to water, were in almost all cases made with either flat surfaces or the cylindrical surfaces of tubes, and results have been arrived at which have more or less guided engineers in determining the area of surface necessary, under given circumstances or conditions, to condense a given quantity of steam. The experiments of Peclet and others gave the conductivity constants which have been very generally used, and showed the heat transmitting capacity of a metal to transmit heat by conduction varied directly as the difference of temperature on the two surfaces, and inversely as the thickness of the conducting plate. Peclet gave 515 units per hour per square foot of plate 1 in. in thickness, and per degree Fah., as the conducting power of copper, and 233 units for iron. Experiments by Messrs. Easton and Amos with a wrought iron tube, 1·5 inch in diameter and 0·0625 in. in thickness—the tube being placed vertically in 3 ft. 7 in. of water, and filled with steam at 212 deg.—gave 230 units per square foot per hour per degree difference of temperature, which is a very much-smaller conductivity than that arrived at by Peclet, if the thickness of the metal is considered. By experiment with a steam jacketed, caldron-shaped vessel, Peclet derived 235 as the conductivity; but from experiments made with steam in long coils, he derived results so much higher than these that doubt has often been expressed as to their accuracy. With a coil of pipe 1·35 in. outside diameter, and 138 ft. in length, 974 units; and with two coils, each 49 ft. in length, and of pipe 1·35 in. inside diameter, 1,020 units were obtained. These results have been looked upon as incredible, especially when compared with those obtained with steam passed through or into straight pipes of comparatively short lengths. The mean of a large number of experiments with bare pipes gave about 500 units; and in the case of a pipe nearly 2,300 ft. in length, but partly covered and in a coal pit plane, 225 units were obtained. All these tubes or pipes were, however, again straight, and, with one exception, comparatively short. These and many other experiments point to the conclusion that not only thickness but length of pipe providing the heat transmitting surface is a very important factor, and that the coil form of pipe is more effective than the straight. We should, perhaps, not have noticed the difference between the efficiency of flat surfaces or of straight pipes and coiled pipes, but that the remarkably high efficiency of some coiled tubes with which we recently made some experiments caused a reference to the figures obtained from previous experiments.

We illustrate a group of the "Compactum" condensers, as fitted on board the S.S. Calabria by Mr. J. Kirkaldy, of West India Dockroad, London, at the time when fresh water was supposed to be wanted in large quantities for the soldiers in the Soudan. Each of these small condensers—there are ten in the group—will condense a minimum of 60,000 lb. of steam per twenty-four hours, or 2,500 lb. per hour; the group would thus provide 25,000 lb., or 2,500 gallons, per hour, or about 66,000 gallons per day. These condensers were tested under Government inspection, with the result that they condensed 128·34 lb. of steam per square foot of tube surface per hour, the steam being at 47 lb. per square inch, or at a temperature of 295 deg. Fah., and the water from the condensed steam passing away at 70 deg., the circulating water being at about 40 deg. The surface is, however, here measured as though the tubes were ordinary tubes of circular section. They are, however, corrugated in the direction of their length, or fluted, and this makes a difference of about 10 per cent. in the actual surface. Making the necessary correction for this, the quantity of water condensed per square foot of surface will be 115 lb. We thus have as the amount of heat conducted by one square foot of this surface per hour 130,410 units, which, taking the mean difference of temperature on the inside and outside of the tubes as 295 — 70 + 2, or 142·5 deg., gives a conductivity of 914·4 per square foot of surface per degree of difference of temperature. These figures agree very closely with those of Peclet, which have been looked upon as inaccurate. Box arrived at the conclusion that these results were incredible, but had neither noticed that the vessel or the tubes experimented with were thin, nor that length of trasverse of the steam had an important bearing on the matter, as we shall see. He gives it as a fact that the conductivity varies inversely as the thickness of the plate, but omits to see that if a plate 1 in. thick will transmit 515 units per hour per square foot and per degree difference of temperature, there should be nothing incredible in the Peclet experiments with a worm 138 ft. in length, and probably not more than, perhaps, a sixteenth of an inch in thickness. In fact, experiment would seem to throw doubt on the relation given by Peclet on the thickness and rate of transmission; for if a copper plate 1 in. thick will transmit 515 units, a plate $\frac{1}{16}$ in. should transmit 8,240, and no experiments seem to support this. Joule found that, by passing water through the annular space between two tubes, one inside the other, and carrying steam, 100 lb. of steam could be condensed per hour, and this would represent about 100,000 units per square foot, and at least 1,000 units per degree of difference of temperature. Experiments mentioned by Rankine, as well as others, show that the quantity of heat which a metal may conduct depends not only on the metal itself, but also upon the disposition of the metal and mode of supplying the medium which is to carry off the heat.

The experiments made on board the steamship Calabria induced us to make some further experiments with similar condensers, fitted with fluted and with plain tubes, and with an experimental condenser of different proportions, but fitted with similar tubes. A condenser containing two coils made of 34 ft. of fluted tubes, one coil within the other, and both tubes of about equal lengths of 0·5 in. and 0·375 in. tubes, the total surface of which was 4·23 ft., or, practically, $4\frac{1}{4}$ sq. ft., was placed at our disposal, and another condenser of similar form, but fitted with twenty-one straight tubes of 0·75 in. outside diameter, presenting 7·9 ft., or, practically, 8 sq. ft., was also at our disposal for comparative test. The steam supplied to the condensers was exhaust steam from a small engine, and the cooling water was from the mains. The result of experiments with these two condensers, briefly stated, was that the fluted tubes condensed almost exactly double the quantity of steam condensed by the plain tubes; that is to say, that a given amount of surface in one of the Compactum condensers has just double the efficiency of the same amount of surface in an ordinary condenser

with straight plain tubes, so that a Compactum condenser may be used of half the usual size. There seems to be but little gain in the use of fluted straight tubes; they must be coiled as under Kirkaldy's patents to do the most work, and the coiling, moreover, causes them to move freely and allow for expansion and contraction, and this prevents the accumulation of incrustation.

The experimental condenser referred to was made with a view to ascertain the minimum quantity of circulating water necessary to condense a given quantity of steam. It consisted of a 6 ft. length of 6 in. cast iron pipe containing two coils of tubes 70 ft. in length, in all 140 ft. of tube, each tube consisting of 30 ft. plain tube 0·375 in. diameter, 21 ft. fluted tube 0·5 in. diameter, 12 ft. 0·625 in. fluted, and 7 ft. 0·75 in. fluted tube, presenting a surface in all of 19·44 sq. ft. Some curious results were obtained in the following experiment, in which the minimum quantity of circulating water is about one gallon to one gallon of steam condensed, and the condenser thus acting at great disadvantage as a condenser, but showing its capacity as a heater. Steam was led to this condenser, the steam passing through the tubes, the pressure in the boiler a few feet away being 61 lb., and may be taken at about 58 lb. at the condenser, and a temperature of 306 deg. The condensed steam passed away at the rate of 62·7 gallons, or 627 lb., per hour, and at a temperature of 96 deg., the circulating water from the mains entering at 62 deg. and passing away as steam at a mean temperature of 225 deg. The heat given up by the steam was thus 306 — 96, or 210 deg., which, added to the latent heat, gives 1,111 units per pound, or a total of 696,597 units. The total surface being 19·44 sq. ft., the units of heat transmitted per sq. ft. = 35,833 units, or per degree of mean difference in temperature under such unique and unfavorable conditions of 241·9, or, practically, 242 units.

In numerous experiments these figures were confirmed, that is to say, that the surface in these condensers gives such a high efficiency that a gallon of circulating water produced a gallon of distilled water from steam at 58 lb. on the square inch. The significance of this fact is that, properly applied, the feed-water to an engine ought to be nearly or quite enough to condense all the steam from the engine, and there is no doubt that the Compactum condensers could be made to do this, but the conditions of working would not often be convenient, and it is seldom that twice the amount of the feed-water could not be obtained. A condenser of this kind acts as a remarkably efficient feed-water heater, as will have been seen from the figures of numerous experiments showing that 10 lb. of steam was condensed with 10 lb. of circulating water, all of which was converted into steam. The trial condenser referred to gave the following figures as the mean of a number of measurements: pressure of steam 58 lb., temperature of circulating water 70 deg., temperature of condensed water 102. One gallon of circulating water in 55 seconds gave one gallon of condensed water in 57 seconds.

It is needless to point out that under these conditions the apparatus apparently gives a higher efficiency as a feed-heater than as a condenser, but this would disappear if a greater mean difference of temperature were maintained. In the experiments the steam entered the tubes at the end where they were surrounded by steam at a lower temperature. If the tubes at the circulation outlet end had been surrounded by water, a much higher duty could have been obtained, just as in the Calabria condensers, and as in the Compactum condensers generally. One of these condensers, for example, of but 5·5 in. by 5·5 in. by 29 in. outside dimensions, will condense 62·5 gallons per hour, so that an almost incredibly large efficiency is obtained per square foot of surface when sufficient circulating water is obtained. In the experimental apparatus, which we might imagine acting as both condenser and heater to an engine, the surface was sufficient to condense all the steam from an engine doing about 30 horse-power with 20 lb. of steam per indicated horse-power, that is to say, about two-thirds of a square foot would be sufficient under the circumstances narrated; but with plenty of circulating water, much less than this would perform the work of a surface condenser. The Calabria condenser tests indicate that about one-sixth of a square foot would perform the work.

Each of the condensers in the Calabria is of the following external dimensions and capacity: 12 in. by 12 in. by 23 in., the filter beneath them being 15·5 in. by 12·5 in. The weight of each is 370 lb.—*The Engineer.*

DOHIS'S ACCUMULATOR OF POWER.

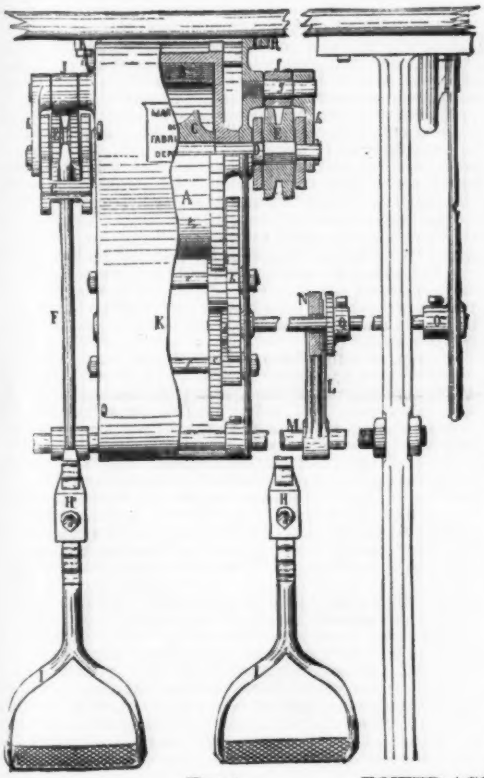
MR. DOHIS has devised a special apparatus called an "accumulator of power," which he applies to the driving of sewing machines. The apparatus permits of a better utilization of muscular power, and also of storing up a portion of it, in case it is not all expended at once, so that it may be used later on.

The annexed figures show the apparatus in transverse section and in elevation. The operator places her feet in the stirrups, I and I', which are affixed to the extremity of vertical levers. In this position she performs motions similar to those made in walking, so as to oscillate the levers.

The motion of these levers is transmitted to the sewing machine as follows:

The transmitting and storage mechanism applied by Mr. Dohis is borrowed from clockwork movements—it being the barrel and spring thereof. The spring, B, is inclosed in the barrel, A, to the side of which it is fixed by one of its extremities, while by its other extremity it is fixed to a sleeve, C, around which it winds, and which is connected with the shaft, D.

This latter carries two channeled pulleys, E and E',



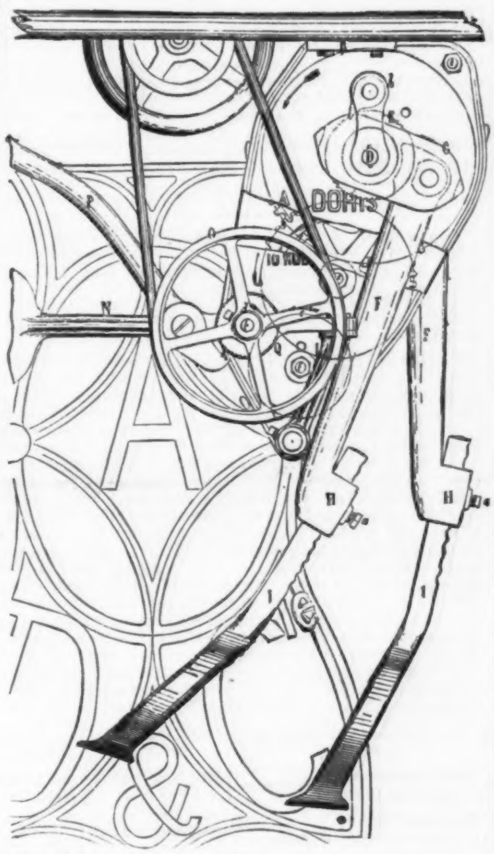


FIG. 1. POWER ACCUMULATOR. FIG. 2.

which are provided with a ratchet toothing. In the channels of the pulleys, E and E', rest the ends of the rods, F and F', which carry the stirrups; and, as the section of the channels is V-shaped, there occurs between the pulleys and rod-ends, when the stirrups are actuated, a sufficient wedging to revolve the pulleys and, with them, the shaft, D. Each of these rods is connected with the shaft, D, by a double strap, G. As for the clicks of the two pulleys, they are on a special axle, *g*.

The rotary motion of the shaft, D, unwinds the spring; and the barrel, then revolving under the impulsion of the latter, drives the pulley, O, through the intermedium of gear-wheels, *b*, *c*, and *d*. The pulley, O, in its turn, transmits motion to the sewing machine through a cord.

The apparatus is rendered complete by two brakes. The first of these, N, called a regulating brake, serves to modulate the velocity by producing a pressure upon the shaft of the pulley, O. The other, P, called a stoppage brake, permits of stopping the machine by acting through its extremity upon a toothed wheel, Q, fixed upon the shaft.

If, while the spring is being wound up, the stoppage brake is depressed, the barrel will be unable to revolve, and the power transmitted will remain in the spring. If, on the contrary, the brake is raised, the spring, giving up at every instant the power transmitted to it, will revolve the barrel and, with it, the entire mechanism.

By means of the regulating brake, the power is utilized only as required, the rest remaining stored up in the spring.—*Chronique Industrielle.*

FREEZING MIXTURES.

IT often happens that a plumber desires to stop the flow of water in a pipe when there is no way to turn it off. He must then resort to the use of some freezing mixture. The one most often used is ice and salt. The cold is produced by the large amount of heat, abstracted from the body surrounded, necessary to change the ice and salt to a liquid state. It is probable that few people know the proper proportions of these two substances to put together to secure the best result. To inform those who have occasion to use such mixtures, *The Sanitary News* has compiled a list of the freezing mixtures readily prepared. The first column gives the ingredients with their proper proportions, the second gives the temperature to which the thermometer sinks in the different mixtures, and the third gives the actual reduction of temperature which takes place in degrees Fahrenheit. The degrees below zero are prefixed by a minus sign.

Mixtures.	Thermometer sinks, degrees F.	Actual reduction of temperature, degrees F.
1. 2 parts snow or pounded ice, 1 part sodium chloride	to -5	
2. 5 parts snow or pounded ice, 2 parts sodium chloride, 1 part ammonium chloride	to -12	
3. 24 parts snow or pounded ice, 10 parts sodium chloride, 5 parts potassium nitrate	to -18	
4. 12 parts snow or pounded ice, 5 parts sodium chloride, 5 parts ammonium nitrate	to -25	
5. 1 part ammonium nitrate, 1 part water	from 40 to 4	36
6. 5 parts ammonium chloride, 5 parts potassium nitrate, 16 parts water	" 50 to 10	40
7. 5 parts ammonium chloride, 5 parts potassium nitrate, 8 parts sodium sulphate, 16 parts water	" 50 to 4	46
8. 5 parts sodium sulphate, 4 parts dilute sulphuric acid	" 50 to 3	47
9. 3 parts sodium nitrate, 2 parts dilute nitric acid	" 50 to -3	53
10. 3 parts snow, 2 parts dilute sulphuric acid	" 32 to -23	55
11. 1 part ammonium nitrate, 1 part sodium carbonate, 1 part water	" 50 to -7	57
12. 8 parts snow, 5 parts hydrochloric acid	" 32 to -27	59
13. 6 parts sodium sulphate, 4 parts ammonium chloride, 2 parts potassium nitrate, 4 parts dilute nitric acid	" 50 to -10	60
14. 9 parts sodium phosphate, 4 parts dilute nitric acid	" 50 to -12	62
15. 7 parts snow, 4 parts dilute nitric acid	" 32 to -30	62
16. 4 parts snow, 5 parts calcium chloride	" 32 to -40	72
17. 2 parts snow, 3 parts crystallized calcium chloride	" 32 to -50	82
18. 3 parts snow, 4 parts potash	" 32 to -51	83
19. 6 parts sodium sulphate, 5 parts ammonium nitrate, 4 parts dilute nitric acid	" 50 to -40	90

THE MANUFACTURE OF TOILET SOAPS.*

By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

LECTURE I.

DISTINCTION BETWEEN TOILET SOAPS AND HOUSEHOLD AND SCOURING SOAPS, ETC.

MOST people, at the present day, have a moderately clear conception of what is meant by the term "a piece of soap," the idea conveyed being that of a substance having the qualities of a lump of ordinary household "yellow soap," or a tablet of "brown Windsor," or of "transparent" soap, or of other choice and more expensive varieties, all possessing in common the property of giving a lather with water, and of assisting the removal of dust and dirt from the hands, etc., when rubbed with water and the soap, so as to form the lather in contact with the skin or the article to be cleansed. Most people know, too, that, instead of soap, various other substances can be used for the purpose of facilitating the removal of grease and dirt from the hands or household articles, etc., such as wood ashes (either as such, or purified by treatment with water, straining clear, and evaporating the solution until a solid mass of "potashes" is left), the ashes of certain seaweeds and maritime plants (*kelp, barilla,* etc.), "spirit of hartshorn" (solution of ammonia), and so-called "Scotch" soda or soda crystals (washing soda), all of which substances belong to a class of bodies chemically classed as *alkalies*,† and differing entirely in character from certain vegetable juices (*e. g.,* the "hyssop," the "soapwort," etc.), and various earthy and clayey matters (*e. g.,* "fuller's earth"), occasionally used for the same kind of purposes. Soaps, in point of fact, are simply alkalies, the properties of which have been, to some extent, diluted and modified by the chemical action on them of various fatty and oily matters; and for our present purpose soaps, as a whole, may be divided into two main ranks, viz., those which are intended for the cleansing and scouring of household furniture, floors, linen, etc., or for analogous purposes in the arts and manufactures (*e. g.,* for cleansing woolen or cotton textile fabrics, before dyeing or subsequently), and those which are prepared with the intention of being employed for personal ablution, *i. e.,* which are intended to be brought in contact with the human skin for the purposes of cleanliness. The latter class, conveniently designated as *toilet* soaps, essentially differ from the former only in the quality of the materials used in their manufacture and the care and skill employed in so conducting the operation and proportioning the ingredients to one another, or in subsequently purifying and refining the crude product, as to obtain, as the final result, *the material in which the*

* Lectures delivered, May, 1885 before the Society of Arts, London. From the *Journal S. A.*

† From the Arabian term *Al Kali*, applied to a particular plant (glasswort), the ashes of which abound in "potash," and have consequently been employed from the earliest ages as a detergent for laundry operations and for the manufacture of glass, etc.

alkali originally used has been all but perfectly transformed into true soap, leaving none uncombined with the fatty matters employed; in other words, a "toilet" soap is essentially a variety of soap *made from choice, selected kinds of fatty matters*, judiciously combined with alkalies in such fashion that *the product contains practically no alkali in excess*, generally spoken of as "free alkali." Some of the ordinary household, laundry, scouring, and manufacturers' soaps in everyday use only differ from toilet soaps proper in that they are made with cheaper and coarser materials, and in a somewhat rougher way; but there are also in use a number of scouring soaps which are purposely made intensely alkaline (by employing alkali in excess during manufacture, or by mixing with the crude soap, before solidification, certain proportions of alkaline matters), so that they may naturally possess a high detergent power;* soaps of this class are obviously wholly unfitted for the special purposes for which toilet soaps are intended, because the excess of alkali purposely introduced renders them far too corrosive in their action upon tender and sensitive skins, especially infants and delicately nurtured ladies. Persons with tough, sound, healthy skins, however, can often use even the most alkaline scouring soaps without material injury (at any rate when not too frequently applied). Accordingly, there are to be found in the market a large number of soaps by courtesy designated "toilet" soaps, and usually sold at relatively low prices, the only claim of which to the title "toilet" soap lies in the fact that they are mechanically cut and stamped into tablets convenient in size and shape for washing the hands, etc. Thanks, probably, to the hardening effect of the gloriously uncertain British climate, the number of persons in this country whose skins are so tough that they can habitually use these alkaline soaps without suffering severely in consequence is sufficiently great to enable a considerable number of soap tablets to be sold, the characters of which are only to be compared with weak mustard plasters or diluted blisters, so far as their rubefacient and generally irritating action is concerned; but the more sensitive and tender skinned of the population suffer greatly from the use of such soaps, and, in consequence, of late years a rapidly increasing demand has sprung up for certain superior kinds of foreign made soaps free from these defects. Unfortunately, price is not by any means necessarily a guide to quality in this respect; and so far as alkalinity is concerned, many of the more expensive soaps are quite as bad as most of the cheapest class, although they, at any rate, possess the advantage of being made from less coarse fatty matters, and being more attractively scented and otherwise finished.

The general characters of toilet soaps, as they exist in trade, then, may be briefly put thus: The better classes, truly deserving the name, are superior varieties of soap, made from selected materials, with special precautions to avoid alkalinity, and in some cases improved and rendered more attractive in appearance by perfuming, tinting, and working into the form of highly finished tablets; while the lower grades are either made from good materials, but in such a fashion as to be highly alkaline, or are simply ordinary household and laundry soaps (or different varieties of such blended together), made from commoner kinds of material, but more or less improved in appearance while working into tablet form. Viewed from this standpoint, it is, unfortunately, the fact that a large proportion of the tablets sold under the name of "toilet soaps" in this country are quite unworthy of that name, being much better suited to the laundry than for the use of delicately nurtured persons as an application to the skin.

EARLY HISTORY OF SOAP MAKING PROCESSES, AND THE NATURE OF THE CHEMICAL CHANGES TAKING PLACE THEREIN.

Although the use of wood ashes, and probably other natural alkaline substances, as aids in cleansing clothing, etc., has been known from a very ancient period,† still no certain historical reference to the products of the combination of these alkalies with fatty matters appears to be extant long prior to the Christian era. Hyssop and other vegetable extracts, fuller's earth, and certain natural alkalies (more especially *natron*, an exudation or efflorescence from the soil of certain localities, or a product of the evaporation of certain natural waters) were known to the early Jews, various references thereto being made in different portions of the Old Testament; but in all probability the materials actually referred to in those passages where the English translation mentions "soap" (or rather "sope") were not the fatty combinations now known by that name. Thus the passage in Jeremiah ii., 22, "For though thou wash thee with niter, and take thee much sope," doubtless refers to *natron*, and not salpeter;‡ while *borith* (translated sope) more probably refers to woodash lye. Again, in the Homeric description of primitive laundry operations in the open, no mention is made of any substance that could be identified as soap of any kind. In the time of Pliny, however, it appears to have been discovered that tallow and woodash lye would form a cleansing compound, such a substance being described by this author; while at the period of the destruction of Pompeii, the manufacture of soap had attained to a considerable degree of completeness, judging from the discovery, in the remains of that city, of what appears to have been a well furnished soap factory.

Not till the present century, however, was the character of the chemical action taking place in the conversion of alkalies and fatty matters into soaps made clear by the labors of Chevreul, from whose researches it results that the essential chemical change is one belonging to the class known as 'single decomposition.'* When vinegar is poured upon natron, not only is a gas expelled, differing from ordinary atmospheric air in that it extinguishes a lighted candle, but further, the sour taste of the vinegar and the acrid taste of the natron are both lost, and instead of these two dissimilar bodies, one substance only results (certain due proportions being observed between the vinegar and the natron); so that the chemical change may be written thus:

$$\left\{\begin{matrix}\text{Carbonic acid gas}\\ \text{Soda}\end{matrix}\right\} + \text{Vinegar} =$$

$$\left\{\begin{matrix}\text{Vinegar}\\ \text{Soda}\end{matrix}\right\} + \text{Carbonic acid gas.}$$

The carbonic acid gas being displaced from combination with the constituent soda contained in natron by the acid of the vinegar. Each of the compounds, natron (or carbonic acid combined with soda) and the resulting "neutral" body (vinegar or acetic acid combined with soda, otherwise termed acetate of soda), belongs to the class of substances termed by chemists *salts*;† and soaps are substances belonging to the same category, their essential composition being this, that soda, or some body analogous thereto, is combined with an acid derived from an oily or fatty matter as starting point, forming a salt of the nature:

$$\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali.}\end{matrix}\right\}$$

Natural oils and fats, however, are not identical with the "fatty acids" derivable from them; they are, in truth, a sub-class of salts, in which fatty acids are associated, not with an alkali or corresponding inorganic body analogous thereto, but with an organic material to some extent analogous to alkalies, but widely different from them in many other respects; this material is *glycerin*, so that the composition of a natural oil or fat may (at any rate in the vast majority of cases) be expressed by the symbol $\left\{\begin{matrix}\text{fatty acid}\\ \text{glycerin}\end{matrix}\right\}$ corresponding with the above written analogous symbol for soap:

$$\left\{\begin{matrix}\text{fatty acid}\\ \text{alkali.}\end{matrix}\right\}$$

The action of single decomposition taking place when soap is generated by the chemical reaction of a fat or oil (a "glyceride") upon an alkali may, then, be expressed in the following form:

$$\left\{\begin{matrix}\text{Fatty acid}\\ \text{Glycerin}\end{matrix}\right\} + \text{alkali} = \left\{\begin{matrix}\text{fatty acid}\\ \text{alkali}\end{matrix}\right\} + \text{glycerin.}$$

To this change (as well as to certain other analogous ones) is applied the term *saponification;* all such reactions being perfectly parallel with the action of vinegar upon natron. Similar changes are brought about in the familiar experiment of the "lead tree" (displacement of lead in arborescent form by zinc, from acetate of lead); or when a bright steel blade is plunged into a solution of a copper salt (*e. g.*, sulphate of copper), whereby a portion of the iron is dissolved, and a corresponding amount of copper deposited on the blade; or when soda is added to the same solution; the reaction in this last case being exactly akin to the production of soap as above, save that in soap making the soap is generally caused to become insoluble in the water present (by addition of salt), while the glycerin remains dissolved therein; and in the soda and copper sulphate experiment, the salt formed by the chemical change (sulphate of soda, the correlative of the soap) remains dissolved, while the copper hydroxide (the correlative of the glycerin), set free as complementary product, is precipitated, or rendered insoluble, thus:

$$\left\{\begin{matrix}\text{Acetic acid}\\ \text{Lead}\end{matrix}\right\} + \text{zinc} = \left\{\begin{matrix}\text{acetic acid}\\ \text{zinc}\end{matrix}\right\} + \text{lead.}$$

$$\left.\begin{matrix}\text{Sulphuric acid}\\ \text{Copper (as metal)}\end{matrix}\right\} + \text{iron} = \left\{\begin{matrix}\text{sulphuric acid}\\ \text{iron}\end{matrix}\right\} + \left\{\begin{matrix}\text{copper}\\ \text{(as metal).}\end{matrix}\right.$$

$$\left.\begin{matrix}\text{Sulphuric acid}\\ \text{Copper (as hydroxide)}\end{matrix}\right\} + \text{soda} = \left\{\begin{matrix}\text{sulphuric acid}\\ \text{soda}\end{matrix}\right\} + \left\{\begin{matrix}\text{copper}\\ \text{(as hydroxide).}\end{matrix}\right.$$

The "fatty acids" thus conjoined with glycerin in natural fats and oils (generally known as "glycerides") are very numerous. The following list comprises a number of the more important of them, together with the chemical formula of the acid, and the leading fatty and oily matters in which it occurs:

Name.	Formula.	Melting point.	Sources.
Lauric acid	$C_{12}H_{24}O_2$	44° C.	Cocoanut oil. Laurel butter (bay fat).
Myristic acid	$C_{14}H_{28}O_2$	54°	Nutmeg butter; to some extent in spermaceti and cocoanut oil.
Palmitic acid	$C_{16}H_{32}O_2$	62°	Palm oil; to some extent in most animal fat.
Physetoleic acid	$C_{16}H_{30}O_2$	30°	Sperm oil.
Hypogæic acid		34°	Earthnut oil.
Linoleic acid	$C_{16}H_{28}O_2$		Linseed oil.
Stearic acid	$C_{18}H_{36}O_2$	69°	Tallow, lard, suet, almond oil, olive oil.
Oleic acid	$C_{18}H_{34}O_2$		
Ricinoleic acid	$C_{18}H_{34}O_3$		Castor oil.
Arachidic acid	$C_{20}H_{40}O_2$	75°	Earthnut oil.
Benic acid	$C_{22}H_{44}O_2$	76°	Oil of ben.
Brassic acid	$C_{22}H_{42}O_2$	33°-34°	Colza oil.

Although these fatty acids contained in natural oils, etc., are in many respects very unlike such acids as oil of vitriol and aqua-fortis, mineral acids of the stronger and more pronounced class, yet all of them have certain features in common with the mineral acids, of which the most salient are, first, that they possess the property of altering the colors of certain substances sensitive to such influences; and, secondly, that they combine with alkalies, destroying the acrid taste and other peculiarities of these substances. As regards their actions on coloring matters generally, acids and alkalies are ordinarily antagonistic, so that the term *antacid* is virtually a synonym for the latter class of bodies; in some instances, the normal tint of a coloring matter is changed in one way by an acid, in another by an alkali, *e. g.*, litmus, normally of a purple or violet hue, becoming full blue in the presence of alkali and red in presence of acid; in others, the color is unaffected by acid, but is changed by alkalies, *e. g.*, turmeric, the natural yellow of which becomes brown-red in presence of alkalies; in yet other cases, alkalies produce no change in the tint, while acids develop a different color, *e. g.*, rosaniline, unaffected by alkalies, but turned crimson by acids. These peculiar color changes are of special interest in connection with soaps, because they afford the means of accurately determining not only how much alkaline matter, as a whole, is present in a given specimen, but also how much of the alkali is present combined with the fatty acids as actual soap, and how much is present in other forms, *i. e.*, what is the proportion of "free alkali" present as compared with the "combined alkali." As already stated, this proportion in a toilet soap truly deserving of the name must not exceed a certain limit, the precise value of which will be more fully discussed in a subsequent lecture. As an illustration of the way in which this proportion may be quantitatively determined, it may be noticed that by making a "standard" acid solution of definite strength, so that a given volume of it (say one cubic centimeter) will exactly neutralize a known amount of alkali (say for example one centigramme of soda, Na_2O), the total alkali present in a given sample of soap can be determined by dissolving a weighed quantity (say ten grammes) in water, adding a measured quantity of the standard acid more than sufficient to neutralize all the alkali in the soap (say 100 cubic centimeters), boiling or thoroughly agitating to decompose all the soap and cause the fatty acids to separate from the aqueous liquid, and then testing the aqueous liquid with an alterable coloring matter as "indicator," and a corresponding "standard" alkaline solution, so as to find out how much of the acid failed to become neutralized by the alkali in the soap. If 25 cubic centimeters of acid remained unneutralized, 75 were neutralized, representing 75 centigrammes of soda, or (relatively to 10 grammes of soap) 7½ per cent. of total alkali. After a somewhat similar fashion the free alkali can be determined, as will be more completely discussed hereafter; if the "free alkali" were found to be 5 centigrammes, then manifestly out of the total 75 centigrammes of alkali in the soap 5 were uncombined, and 70 were present combined as actual soap; so that the free alkali in such a case would represent $\frac{5}{70} = \frac{1}{14}$ of the combined alkali, a proportion far too large for a high class toilet soap, although much below that subsisting in many British made soaps, even of the more costly kinds.

A soap, in the widest sense of the term, implies a compound of a fatty acid with an alkali, or other metallic derivative capable of playing the part of an alkali, glycerides not being classed as soaps, for the reason that glycerin, although capable to a certain extent of playing the part of an alkali, is neither a metallic derivative nor an alkali itself. Soaps where the metallic constituent is derived from lime, lead, iron, and such like substances, although very important compounds in reference to certain special manufactures and trades (*e. g.*, in the preparation of hard fatty acids for candle making and in the manufacture of plasters and other articles used in pharmacy), are not employed intentionally in the manufacture of toilet soaps; and although such compounds are unavoidably formed to minute extent in the ordinary processes of soap boiling (owing to presence of lime in the water used, and iron rust from the vessels employed, and such like causes), and although they present many points of interest to the scientific chemist, yet their discussion on the present occasion is somewhat foreign to the matter in hand, which essentially deals with the preparation, for purposes of personal ablution, of choice varieties of substances, substantially consisting of compounds of fatty acids, derived from certain selected sources, with alkalies, and more especially with the alkali soda.

MATERIALS EMPLOYED IN SOAP MAKING.

Besides the fatty and oily matters above mentioned as examples, a large number of other analogous substances, derived not only from natural sources, but from various waste products, are employed in the manufacture of soaps of different qualities. As regards vegetable sources, it may be noticed that comparatively few products used as food by human beings or the brute creation are entirely destitute of substances of the nature of oils as constituents; such substances as seeds and nuts (*e. g.*, wheat and oats, rice and linseed, walnuts, chestnuts, hazelnuts, and cocoanuts) more especially may be mentioned as more or less markedly oleiferous. Those substances which contain comparatively large amounts of oil usually yield it by simple pressure, or "expression," as, for example, olives, cottonseed, and linseed; others, such as rice, containing too small percentages of oily matters to yield them in quantity by mechanical agencies only, can yet be shown to be capable of yielding them by treatment with appropriate solvents, capable of dissolving out the oily matter and leaving the vegetable tissues, starchy matters, etc., undissolved. This method of treatment is often used in combination with pressure, the majority of the oil being expressed, and the "marc" or residue left being then treated with solvents (such as benzene or bisulphide of carbon), for the purpose of gaining the remainder.

Animal tissues are more usually "rendered," *i. e.*, heated either alone or in contact with water, so that the fatty matters may be rendered fluid, and (being lighter than water) may be skimmed off from the top; sometimes chemical agents are also employed for the purpose of decomposing the tissues in which the fat is embodied. Processes of this kind often result in the evolution of the most abominable stenches from the melting pans, due to the decomposition of nitrogenous animal matter by the heat or the chemicals employed; in fact, it is chiefly the performance of this kind of operation which has gained for soaperies their unenviable reputation as sources of malodorous emanations. Even in the comparatively simple processes of

* "Cold water" soaps, "marine" soaps, "soft" soaps, and certain other kinds largely impregnated with silicate of soda, etc., are familiar examples of this class of products.

† The use of wood ashes, and indeed of ashes of other kinds, for scouring purposes, is far from extinct at the present day. A remarkable illustration of this was afforded in Rome a few weeks ago, according to a correspondent of the *Times*. An ancient tomb being dug up, a quantity of ashes found therein was appropriated by a workman, and sent home to his wife for use in washing; these ashes, it subsequently appeared, were the cremated remains of the Emperor Galba, there deposited some eighteen centuries ago "To what base uses we may come!"

‡ The above was written before the appearance of the Revised Version, in which the passage is made to read, "For though thou wash thee with lye, and take thee much sope." On the other hand, the passage in Proverbs xxv., 22, referring to "vinegar upon niter," remains the same in the Revised Version (save marginal note, "or *soda*"). The entire force of the illustration is lost by the use of the word *niter*, *i. e.*, saltpeter—for this salt produces no visible result of any kind on intermixture with vinegar; whereas natron—*i. e.*, crude carbonate of soda—develops a copious froth, the hollowness and rapid subsidence of which is in keeping with the effect of singing "songs to an heavy heart."

* Chemical changes may be classified into four orders:

Synthetic .. $A + B = \left\{\begin{matrix}A\\B\end{matrix}\right.$

Analytic ..... $\left.\begin{matrix}A\\B\end{matrix}\right\} = A + B$

Of single decomposition...... $\left.\begin{matrix}A\\B\end{matrix}\right\} + C = A + \left\{\begin{matrix}C\\B\end{matrix}\right.$

Of double decomposition. ... $\left.\begin{matrix}A\\B\end{matrix}\right\} + \left\{\begin{matrix}C\\D\end{matrix}\right. = \left.\begin{matrix}A\\D\end{matrix}\right\} + \left\{\begin{matrix}C\\B\end{matrix}\right.$

The bracket signifying chemical union together of the constituent forms of matter, A, B, C, D.

† Because kitchen salt, or chloride of sodium (which may be conveniently regarded as a compound of the alkali soda with a peculiar acid, hydrochloric acid), is one of the best known members of this class.

purifying crude tallow by fusion, etc., vapors are usually evolved of so unpleasant a nature as to demand, in most localities, their destruction by passing through a fire or other deodorizing agent, instead of being allowed to pass into the atmosphere; while the recovery of grease from bones, tannery refuse, hide clippings, intestines, defunct horses, dead cats and dogs,* fished up from ponds and rivers, and similar more or less decomposed animal sources, is often still more offensive, as may readily be imagined.

Various manufacturing operations (*e. g.*, textile fabrics industries) demand the use of large quantities of soap for cleansing operations; greasy matters from the waste washwater of such establishments are nowadays often regained in large quantities, and used over again. Rags and cotton waste, employed for cleaning machinery, etc., are often subjected to treatment with solvents for the purpose of extracting the oily matters with which they become saturated, the cotton being then washed and used over again; this cotton waste grease recovery is quite a trade of itself in some localities where machinery is largely used. Of late years the use of hydrocarbon lubricants (from petroleum and paraffin, or shale oils, etc.) has greatly interfered with the value of the grease thus recovered, these materials being incapable of forming soaps.

In connection with all such products recovered from waste materials (and even to a slight extent the last portions of oil obtained from olive marcs and analogous vegetable sources by means of certain solvents) it is to be noticed that, as a general rule, the nature of the materials from which the greases are extracted is such as to cause the fatty matters ultimately obtained to be more or less colored and malodorous; and even after the employment of deodorizing chemical agents, an unpleasantly smelling product is apt to be developed during the process of treatment with alkali to form soap; in consequence, these instances are mostly incapable of use for the finer varieties of toilet soaps, but they are pretty largely employed for the coarser kinds of scouring soaps, which, as already stated, are to a great extent identical with some of the lower grades of tablets sold for the purpose of personal ablution, although they really bear to true toilet soaps about the same relationship that the coarsest sour peasant's rye bread does to the finest triumphs of the baker's craft.

As regards the sources from which alkalies are derived, it may be noticed that the oldest sources of natron or soda (efflorescences from certain soils, and the saline matters left on the evaporation of the water of certain lakes) are no longer available commercially, the ashes of certain maritime plants having long ago superseded them, and having been themselves disused in favor of chemical processes whereby rock salt is transformed into soda. *Kelp*, the residue left on incineration of seaweed, and *barilla*, the similar ash of "sal soda," and other analogous plants, were for a long time the chief sources of soda, thus leading to the use of the term "marine alkali," as applied to this substance; but, during the last century or so, the production of soda from these sources has gradually declined, rock salt (or other form of culinary salt derived from brine springs, sea water, etc.) being converted into alkali by means of a series of processes essentially consisting of treatment with sulphuric acid, and heating the resulting "saltcake" with small coal and chalk or limestone, finally separating the soluble alkali from insoluble calcareous matter, etc., by means of water. Of late years a simpler method (the "ammonia process") has superseded this one to a large extent, the essential feature in this system being the treatment of salt in watery solution with ammonia and carbonic acid gas under pressure.

Somewhat similar remarks apply to potash, the "vegetable alkali" of the alchemists. For a long period this substance was obtained in a more or less impure form by treating the ashes of burnt wood, etc., with water, and evaporating down the clarified solution obtained, thus obtaining "potashes" (*query*, ashes treated with water in a pot ?), which, when refined, gave the purer and whiter material "pearlash," but latterly large deposits of a mineral analogous to rock salt, but containing the metal potassium instead of sodium, have been largely worked into the alkali potash by a method substantially the same in principle as the salt cake (or "Leblanc") process used in the soda manufacture. Some amount of potash also is now obtained by the calcination of "suint," or the greasy matters washed out of raw wool before spinning and weaving into cloth. This substance is, in fact, the inspissated perspiration of the sheep, and is remarkable in that while it largely consists of a kind of natural soap, the alkaline matter present in this soap is almost wholly potash, soda being contained to only a comparatively small extent. It may be noticed that in the woolen trade the use of potash soaps instead of soda soaps for cleansing the fabrics is often essential, as the soaps made from the latter alkali are sometimes apt to damage the material, by deteriorating its finish in a way not so noticeable when potash soaps are employed.

It is to be remarked in this connection that potash soaps are usually considerably softer in consistency than soda soaps made from the same materials, more especially when certain "fish oils" or "drying oils" are largely used in the manufacture; accordingly, soaps are in practice divided into two classes, viz., soft soaps, which mainly contain potash, and hard soaps, chiefly containing soda as constituent alkali. The great majority of toilet soaps belong to the latter division; a few toilet creams and shaving soap pastes, etc., however, fall into the former class.

Ammonia is but little employed as a constituent of soap proper as used for toilet purposes, although various processes have been patented involving the intermixture of ammonia with potash or soda soaps, for the purpose of increasing detergence, or of obtaining other real or supposed advantages. The chief sources of ammonia employed industrially are the liquors (mixed with tar) obtained by the action of heat upon coal, shale, bones, and other allied organic matters; and more especially the "gas liquor" resulting from the distillation of coal in ordinary gasmaking. From such liquors pure solution of ammonia, or "spirit of hartshorn," is obtained by the use of appropriate purification methods; when brought into contact with the various fatty acids in a just molten condition, and well incorporated therewith by mechanical agitation, solution of ammonia combines with the acids, forming "ammonia soaps" of perfectly definite character, but considerably more prone to decomposition than the soaps of the fixed alkalies, potash and soda. In presence of a slight excess of ammonia, they usually dissolve completely in cold water, forming solutions that froth and lather precisely as ordinary soda soaps; but on boiling the solution, ammonia is given off, and a residue of fatty acids combined with little or no ammonia is left.* The same result is brought about more slowly at ordinary temperatures. When an ammonia soap is allowed to stand under a bell jar, along with a dish of sulphuric acid (to absorb water and ammonia given off), ammonia is rapidly lost, until the amount left equals one-half that chemically equivalent to the soda present in neutral soda soap from the same fatty acid; the "diacid salt" thus obtained usually loses ammonia on further standing, but far less rapidly than the original salts; the diacid ammonia salts of stearic and lauric acids (the leading constituents of tallow and cocoa oil respectively) appear to be considerably less unstable under these conditions than those of oleic and ricinoleic acids (from olive and castor oils respectively).

* This branch of industry appears to be less cultivated in London than in Paris, to judge from the floating *debris* to be seen in the Thames whenever one takes a water excursion thereon. In the French capital, the manufacture of grease and manure from the Seine flotsam and jetsam (and analogous household refuse, etc.) has for years been a source of profitable manufacture. On the other hand, it may be noticed that the proverbial expression concerning "making butter from Thames mud" owes its origin to a somewhat analogous mode of utilization of waste impure grease derived from still less attractive sources. Much of the fatty matter used as food in large towns passes undigested through the bodies of the consumers, and, in consequence, films of greasy matter often float up to the surface of the water in the still reaches of the streams into which the town sewers discharge; this grease is sometimes collected by the simple device of letting bunches of grass or other floating masses, fixed to a line, remain in the water for a long time, so as to become coated with the slimy, fatty matters brought in contact with them by the gentle motion of the water; but it is doubtful whether grease thus obtained is susceptible of being sufficiently purified to fit it for sale as an edible substance, such as butterine, without enhancing its cost too much to render its use for this purpose profitable, although, after some purification, it is quite available for making coarse grades of soap.

* It is noticeable in this connection that both potash and soda soaps are affected by hot water in a somewhat analogous fashion, the neutral salts breaking up into free alkali and a compound of fatty acids with less alkali than is requisite to form a neutral soap; this chemical decomposition, effected by water, or *hydrolysis* as it may be conveniently termed, is of the utmost practical importance as regards the detergent properties of soap, and will be more fully discussed in a future lecture.

CAUSTICIZING OF ALKALIES.

One important point in connection with the alkalies used in soap making must not be lost sight of, viz., that fatty matters are not so readily acted upon by these substances when they are in the same chemical condition as in natural natron and borith (or wood ashes) as they are when these "mild," or "carbonated," alkalies have been subjected to an action which renders them more "quick," or "caustic;" in the former case, the saponification takes place slowly, and often only imperfectly, even after long continued boiling; while in the latter, the conversion into soap and glycerin is much more rapid. As we have seen, when vinegar is poured upon natron, a vigorous effervescence takes place, due to the displacement of carbonic acid gas by the acetic acid of the vinegar. Now, although carbonic acid is a very weak acid, it is, nevertheless, strong enough to hinder materially the action of carbonated alkalies upon fatty matters, so as to form soap and glycerin; in many cases the reaction will not take place at all (at least for practical purposes) unless a high temperature in a pressure boiler or other analogous apparatus be employed. Accordingly, it is usually necessary to remove the carbonic acid from the alkali before using it for preparing the soap, which operation is spoken of as "causticizing," or rendering "quick," the operation being, in point of fact, chemically of the same nature as that in virtue of which limestone is converted into quicklime, only differing in the way in which the carbonic acid is withdrawn; in the case of burning limestone into quicklime, the application of heat alone causes the limestone to break up into two constituents, viz., carbonic acid gas, which escapes with the products of combustion used to generate the requisite heat in the kiln, and quicklime, which remains behind; the chemical change being of the nature known as "analytic" (*i. e.*, change of decomposition, or breaking up of complex matter into more simple forms), and expressible by the following scheme:

$$\left.\begin{array}{c}\text{Carbonic acid gas conjoined}\\ \text{with quicklime}\end{array}\right\} = \left\{\begin{array}{c}\text{Carbonic acid gas in}\\ \text{the free state}\end{array}\right\} + \left\{\begin{array}{c}\text{Quicklime in the}\\ \text{free state.}\end{array}\right.$$

In the case of carbonate of soda or of potash, the carbonic acid cannot be conveniently withdrawn in this way; but by dissolving the carbonated or "mild" alkali in water, and then boiling up with quicklime, the carbonic acid is taken away from the alkali by the lime, reproducing the same chemical compound of lime and carbonic acid as constituted the original limestone before burning, and setting free the true or "caustic" alkali in accordance with the following scheme:

$$\left.\begin{array}{c}\text{Soda (or potash) conjoined}\\ \text{with carbonic acid}\end{array}\right\} + \text{Quicklime} = \left.\begin{array}{c}\text{Quicklime conjoined with}\\ \text{carbonic acid}\end{array}\right\} + \left\{\begin{array}{c}\text{Soda (or potash) in}\\ \text{the free state.}\end{array}\right.$$

This property of quicklime, of converting "mild" alkalies into "caustic" or "quick" alkalies, has been known for a long period, although the true explanation of the action belongs to the beginning of the era of modern chemistry; of necessity it follows that if the caustic alkali differs from the mild alkali in not containing carbonic acid associated, no effervescence due to the escape of this gas can ensue on pouring either vinegar or any other stronger acid on the caustic alkali, or into the solution thereof. This nonescape of gas is, in point of fact, utilized as a practical test of the efficiency with which the causticizing process has been carried out, the boiling of the carbonated alkali with quicklime being continued until a sample of the clear liquor (after the lime used has subsided) no longer gives off bubbles of gas on treatment with excess of a mineral acid, the causticized alkaline liquor or "ley" (otherwise spelt "lye") being only then in a fit condition for preparing soap by boiling with fatty matters.

It is somewhat remarkable that quicklime will not thoroughly causticize alkaline carbonates, such as natron, if the solution be too concentrated; in order to produce complete withdrawal of the carbonic acid from the alkali, the liquid must not be more rich in soda than corresponds with about the sp. gr. 1·10 to 1·11. Formerly, soap makers mostly bought artificial natron (soda ash) from the alkali makers and causticized it themselves; but of late years alkali makers have largely manufactured caustic soda for soaperies, etc., in the solid form, by evaporating down the causticized soda liquor, so as to render it unnecessary to carry out this part of the process in the soap works, the solid caustic being simply dissolved in water and used as required.

CLASSIFICATION AND GENERAL CHEMICAL CHARACTERS OF SOAP MAKING PROCESSES.

The processes in actual use for the manufacture of soap on the large scale are tolerably numerous as regards the number of modifications in general detail rendered necessary or convenient in certain cases; but as regards their general principles they may be conveniently ranked in four leading classes or groups, viz.:

Group I.—Processes in which fatty acids (or fatty and resinous acids) in the free state are directly neutralized with alkalies (carbonated or caustic) so as to form soaps necessarily devoid of glycerin as a primary constituent.

Group II.—Processes in which the fatty glycerides are treated with alkalies in such a fashion as to saponify them, forming soap and setting free glycerin, the arrangements being such that these two complementary products are not separated from one another, but remain permanently intermixed.

Group III.—Processes in which fatty glycerides are saponified by alkalies in such a way that the soap and glycerin formed are separated from one another during manufacture, so as ultimately to produce soaps devoid of glycerin as an intermixed constituent.

Group IV.—Processes virtually consisting of combinations of methods of some or all of the preceding types.

Besides these leading methods, however, there are numerous subsidiary processes, through which soaps made in accordance with one or more of these methods are subsequently put, either separately or jointly, for the purpose of finally obtaining improved finished products in the form of cakes or tablets for toilet use.

The processes of the first class are comparatively little used in the manufacture of toilet soap, especially those of superior kinds. In the manufacture of hard candles, various methods are in use for converting natural oils and fats into free fatty acids, with formation of glycerin (either obtained as such, or more or less destroyed by secondary reactions in the process). The mixed fatty acids thus obtained yield by pressure a fluid portion (chiefly consisting of oleic acid) and a hard, far less fusible solid mass (mainly stearic and palmitic acids), the latter being the substance required for candle making.* Among the various applications of oleic acid thus obtained, one of the leading ones is the conversion into soap by direct saturation with alkali, the chemical change being then a synthetic change, or one of direct union, the converse of the analytic change (or one of decomposition or breaking up) taking place during the conversion of limestone into quicklime, and being typified by the following scheme:

$$\left.\begin{array}{c}\text{Soda}\\ \text{(or}\\ \text{potash).}\end{array}\right\} + \text{Oleic acid} = \left\{\begin{array}{c}\text{Oleic acid conjoined}\\ \text{with soda}\\ \text{(or potash).}\end{array}\right.$$

The crude oleic acid obtained in the candle factory is generally more or less strongly colored brown, and the soaps made from it often share this peculiarity; as a rule, they are rather of the household or scouring class than of the more refined and superior toilet class; but by proper treatment, the oleic acid of the candle maker can be made to yield (especially when purified, and the neutralized mass admixed with soaps made from other kinds of material) a very fair kind of toilet soap.

When ordinary resin (crude or refined) is boiled with alkaline solutions, a substance is similarly formed by the direct combination of the resinous acids present with the alkali, closely akin to some kinds of soap; this product is somewhat largely employed as a constituent of certain kinds of mixed soaps (resin soaps), the preparation of which, as a whole, rather belongs to the fourth class of processes than to the first.

Processes of the second class may conveniently be subdivided into three groups, viz.:

a. Where the fatty matter to be treated and the alkali (previously causticized) are incorporated together, at temperatures lower than the ordinary boiling heat, and allowed to remain in contact until the saponification is complete, without concentration by boiling down. Such processes are usually known as "cold" processes, not that the action is actually carried out in the cold, but because the temperature is relatively low throughout; the alkaline lyes are ordinarily used of considerable strength, so that there is not so great a quantity of water present as to prevent the resulting product setting firm on cooling and standing. Processes of this kind are largely used in toilet soap manufacture.

b. Where the fatty matters and alkaline lyes are boiled together in vessels, under ordinary atmospheric pressure, a certain amount of concentration by evaporation of water taking place during the process. This method is adopted in the manufacture of soft soaps (essentially potash soaps, but often containing a certain amount of soda) and in certain classes of hard soaps, especially those of the marine kind (mainly made from cocoanut oil, the soda soap of which will lather with sea water, which most other soaps will not do).

c. Where the fatty matters and alkaline lyes are made to react upon one another, under increased pressure, and at a temperature above that of the boiling heat under ordinary pressure. Methods of this class are rarely, if ever, used for the production of the choicer kinds of toilet soaps, as the increased heat renders the product more liable to possess an odor objectionable for articles intended to be delicately perfumed.

* During the last few years a process has been patented (but as yet apparently not extensively used) for the preparation of free fatty acids, either for soap making by direct saturation or for separation into solid and fluid acids by pressure, which depends on the circumstance that, at a moderately high temperature—obtained in a pressure apparatus—and in presence of aqueous ammonia, oils and fats are saponified, forming ammonia soaps and glycerin, the former being to some extent permanent under pressure, but readily breaking up into free ammonia and free fatty acids when heated under the ordinary pressure.

In all three of these methods the amount of fatty matter and alkali must be carefully proportioned to each other, the amount of alkali relatively to the fatty matter varying with the nature of the acids, of which the fatty matter contains the glycerides, and being the greater the lower the chemical equivalent of the fatty acids present. If too little alkali be added, the resultant soap contains unsaponified fat, and is greasy; if too much, it contains more or less "free alkali," and is consequently rendered of inferior quality for toilet use.

Processes of the third-class constitute those by which the majority of the ordinary scouring and household soaps in everyday use are prepared. According to the scale on which they are carried out, and the nature of the materials employed, the manipulation and mode of treatment is subject to considerable variation; but, as a whole, these processes may be said to possess in common the distinctive feature that the fatty matters serving as basis are boiled with comparatively weak alkaline solutions until saponification is completed, or nearly so, when the glycerin and soap are separated by the addition of salt, which, dissolving in the water, forms a brine in which the glycerin is soluble and the soap insoluble, so that the latter separates from the mass as a soft, molten paste, which is put through various purifying and finishing stages before casting in moulds, in which it solidifies into blocks which are subsequently cut up into bars, etc.

Among processes of the fourth or mixed class may be mentioned more especially the methods generally used for the preparation of "yellow" or resin soaps, in which a soap prepared by the third or boiling process is admixed with another prepared by saturating resin with alkaline lye, and the mixture then purified and cast into blocks; or in which a partially boiled soap, containing excess of caustic alkaline lye, is treated with resin directly so as to form the resinous soap in the body of the mass, the final product being purified, etc., as before. In a similar fashion various other classes of soap are occasionally prepared by intermixing with a boiled soap a quantity of caustic alkali, and then adding a glyceride, so as to produce a sort of combination of boiled soap with cold process soap; or by other analogous modes of treatment. As a rule, however, these mixed soaps are prepared by making each kind separately, and then intermixing them thoroughly, either while freshly made and before cooling, or subsequently by remelting them together and so blending them. This process of remelting is one of the most extensively used of the subsequent processes through which soaps manufactured in one or other of the above ways are put in order to "refine them," and improve their quality. In many cases small quantities of additional constituents are added during the remelting, for the purpose of giving distinctive qualities; in others, the constituent soaps are simply blended, tinted, and finally perfumed by addition of fragrant oils, etc., at as late a period as possible consistent with due intermixture to diminish the injurious action of prolonged heating upon scents. A mechanical mode of blending without heating, known as "milling," has of late years come largely into use, on account of the possibility of using more delicate perfumes in this way, and other advantages.

In the strict sense of the term, "refining" should indicate putting the original stock soaps through processes which will render the resulting mass more pure and suitable for application to the skin. Certain processes of the kind are actually in use, the object of which is to diminish the amount of free alkali present, either by mechanical means or by chemical modes of treatment finally resulting in the same effect, or by clarifying and purifying the mass by solution in spirit. These processes will be discussed more fully in a subsequent lecture. It unfortunately happens, however, that with a large portion of the toilet soaps sent into the market, not only are such processes not adopted, but, on the contrary, methods of treating the soap are largely used *which add to the alkalinity*, thereby greatly impairing its value from the point of view of suitability for habitual use by persons possessing tender and sensitive skins, the reason for the adoption of these methods being either for the sake of improving the grain of texture of the mass (an improvement dearly purchased at the expense of deterioration in quality), or of communicating greater hardness and durability. The first result is usually sought to be effected by "pearlashing, *i. e.*, adding to the melted mass a proportion of pearlash (or refined potashes), which brings about a remarkable chemical change, viz., the transformation of soda soap into potash soap, with simultaneous production of carbonate of soda instead of carbonate of potash, and the admixture of these products with the original mass causes a marked alteration in its physical character. The second result is often attained by similarly incorporating into the mass "soda crystals," which addition causes (especially with certain kinds of fatty acid soaps) a notable stiffening and hardening of the whole, so that a firm mass results, even if a moderately large amount of water be present. The same effect can also be produced by the employment of certain neutral salts, *e. g.*, sulphate of soda and common salt.

Concerning the use of these materials in the production, at a cheaper rate, of ordinary household soaps, which have been increased in bulk by more or less copious addition of water and "filling," there is much to be said on both sides of the question; but no two opinions are possible in reference to toilet soaps. Any considerable amount of even a neutral compound (like common salt) is objectionable in a soap intended to be used by persons with sensitive skins and delicate complexions; and *a fortiori* alkaline salts, such as soda crystals, are substances the presence of which should be carefully guarded against in such products. Experience of the deleterious action of highly alkaline British soaps leads many to the use, by preference, of various brands of Continental origin, in which this fault is avoided. These "skin soaps," as they may be termed, are often notably more costly than ordinary British makes (from one to several francs per tablet being a usual range of price); but there appears to be no reason, beyond insular prejudice, why equally good articles should not be prepared at home at far lower prices; and recently the British soap trade has shown signs of becoming alive to the fact. As matters stand, however, at the present moment, it by no means follows that a high-priced British made soap is an article to be recommended from the point of view of its quality *as a soap*, although it may be made by a perfumer of the highest reputation in this particular line, and may be well worthy of that reputation when viewed simply *as an article of perfumery*.

On the other hand, it may be remarked that there are in the market a large number of articles sold at low prices (penny and two-penny tablets) under the name of "toilet soaps," the qualities of which, as a rule, hardly justify the application of this term to them. These soaps are mostly ordinary boiled unrefined household soaps (often at best only of second-rate quality as regards the fatty matter used as basis), more or less tinted and scented with cheap essential oils, and more especially with mirbane or artificial oil of almonds (nitro-benzene), so as to disguise the faint or unpleasant odor derived from coarse fatty matters. The better substances of this class have usually been more or less refined, and are accordingly not remarkably alkaline, and consist either of ordinary "yellow" or resin soaps, or of analogous "fitted" nearly neutral household soaps, worked into tablet form instead of bars; and of them it may be said that at least they are better value for the money than are many articles sold at much higher prices. But of the inferior kinds of tablets of this description but little can be said in praise, or even in mitigation of condemnation. Not only as a rule are they made without any attempt at refining from cheap, and often rank, fatty matters, but further, in many instances, they are excessively "watered," saline matters (notably sulphate and carbonate of soda) being copiously added to harden and "close up" the mass. Sometimes they are made of little but cocoanut oil, with a great excess of caustic alkali, and sometimes an admixture of sugar (this variety, however, is more frequently made abroad than in England); they then possess the doubtful merit of rendering a razor almost superfluous when used as shaving soaps, the alkalinity being almost sufficient to destroy the tenacity of hair without any cutting instrument being required; unfortunately, the epidermis is apt to be equally causticized, to the great discomfort of the user. Soaps that have been heavily watered are always apt to get out of shape by exposure to air, through shrinkage in drying; and often to become simultaneously covered with a white saline efflorescence, caused first by the "sweating" out of liquid from the interior, and secondly by the evaporation of the water, leaving behind a more or less crystallized mass of the salts used for hardening, which were dissolved in the liquid. When any noticeable efflorescence is produced on a tablet on keeping, there is at least a high degree of probability that an undue amount of alkalinity is possessed by the soap, together with the certainty of the presence of saline matter in quantity not likely to be beneficial to tender skins; while it is not at all unlikely that the same desire for cheapening that has led to undue sophistication with water and salts has also caused the employment of the cheapest and coarsest fatty matters; wherefore, *all such soaps should be studiously avoided* by persons at all subject to skin irritation of any kind.

It may be noticed, in passing, that the practice of "watering" household soaps, and "closing up," by addition of saline matters, is nowadays carried out to such an extent, and so ingeniously, as to be almost a fine art, so that there is a proverbial expression concerning this class of trade, referring to "making water stand upright" as a main source of profit; and that as regards the amount of foreign matters that can thus be incorporated (especially when cocoanut oil is freely used as part of the fatty matter, this substance lending itself to the practice better than almost any other), it is by no means uncommon to find on analysis less than one-sixth (16·7 per cent.) to be actual soap, the balance being water with saline matter added, to close or harden the soap; so that the soap trade in these matters completely leaves behind the most ambitious milkman that ever resorted to the "cow with the iron tail" to increase his stock. On the other hand, it is to be said that the general public will persist in demanding soaps (and most other goods) at prices quite inconsistent with a high percentage of genuine ingredients, and that the heavily watered and highly salted kinds of soap possess at least certain good qualities to a greater extent than might at first sight be expected from their composition; thus the addition of a considerable quantity of sulphate of soda solution, crutched into the soap just before solidifying, not only enables the price to be reduced so as to meet the demand, but it also actually hardens the soap (partly from the crystallizing of the saline solution, partly from a peculiar physical action on the soap), and thus prevents it from wasting as rapidly in use as it would do were water only added. Again, the addition of a large amount of silicate of soda, aluminate of soda, carbonate of soda, and other alkaline compounds not only produces this hardening effect to a greater or lesser extent, but also adds to the detergent power of the soap; so that for household cleansing purposes, these "doctored" soaps are not really as uneconomical and objectionable as they might be supposed at first sight to be, although for toilet purposes they are of course utterly inadmissible.

In connection with the general chemistry of the manufacture of soaps, and more especially with the processes involving "cutting" or separation of more or less perfectly formed soap from its solution in water by addition of saline matters, and especially of common salt, some curious points relating to the chemical and physical principles involved in the action may be here adverted to. It has long been known that if a potash soap dissolved in water be "cut" with common salt (chloride of sodium), the two alkalies present, potash and soda, and the two acids, hydrochloric acid and the fatty acids of the soap, change places in virtue of a class of change known as "double decomposition," analogous to that ensuing when the same common salt (soda conjoined with hydrochloric acid) is brought into contact with solution of nitrate of silver (silver conjoined with nitric acid). The two kinds of chemical change may be expressed by the following schemes, the potash soap being considered as consisting of potash combined with stearic acid:

{Stearic acid conjoined with potash} + {Hydrochloric acid conjoined with soda} =
{Stearic acid conjoined with soda} + {Hydrochloric acid conjoined with potash}

{Nitric acid conjoined with silver} + {Hydrochloric acid conjoined with soda} =
{Nitric acid conjoined with soda} + {Hydrochloric acid conjoined with silver}

In consequence of this change, it is impossible to manufacture soft soaps by processes involving salting out with common salt, because the addition of this substance would convert the soft potash soap into hard soda soap, potassium chloride being formed as a complementary product. On the other hand, this mutual decomposition is available for the manufacture of hard soda soaps under circumstances where caustic soda is less readily obtainable than potashes, *e. g.*, where wood ashes are obtainable readily in districts a long way from commercial centers where soda ash and caustic soda can be bought;* and accordingly in certain districts it has long been the practice to saponify grease and fatty matters with a potash lye prepared from wood ashes and lime, and then to add salt for the purpose of obtaining a comparatively hard soda soap. At the present day, however, this reaction is comparatively but little used, at any rate in this country; it is noticeable that the soda soap thus formed always retains a certain amount of admixture of potash soap, which communicates to the whole mass certain desirable properties as regards grain and texture, etc.; accordingly, it is now frequently the practice to produce the same result in other ways for the purpose of securing these advantages, the most usual methods being either to employ a mixture of caustic soda and caustic potash to act on the fatty matters in the first instance, or to blend together (by remelting or otherwise) potash and soda soaps in due proportion, or to add a certain quantity of pearlash (purified potashes) to soda soap, which last process has, as already stated, the great disadvantage of increasing the alkalinity of the soap. The *rationale* of this last process appears to be (in accordance with the result of investigations made in my own laboratory, with the co-operation of Mr. C. Thompson) the formation of potash soap and carbonate of soda in accordance with the following scheme:

{Fatty acids conjoined with soda} + {Carbonic acid conjoined with potash} =
{Fatty acids conjoined with potash} + {Carbonic acid conjoined with soda}

This reaction is of interest, inasmuch as it exhibits the inverse transformation of that occurring when common salt is added to a potash soap, potash being displaced from combination with fatty acids by soda in the one case, and *vice versa* in the other. Both changes, in point of fact, occur in accordance with a general rule applying in such cases, viz., that when potash and soda are simultaneously present in contact with two acids jointly equivalent to the sum of the two alkalies, there is a marked tendency for the potash to unite with the stronger acid, and for the soda to unite with the weaker one. Hydrochloric acid being a stronger acid than the ordinary fatty acids, while carbonic acid is weaker than these, it results that if fatty acids and hydrochloric acid constitute the pair, the potash unites by preference with the hydrochloric acid, and the soda with the fatty acids, forming soda soap; while if fatty acids and carbonic acid constitute the pair, the potash will unite by preference with the fatty acids, forming potash soap, leaving the soda to combine with the carbonic acid.†

It is to be noticed, in connection with this general rule, that we find that, under certain conditions, changes may be brought about which are apparently in opposition to it; in point of fact, the two acids and the two bases always so associate themselves as to give rise to *four* salts, viz., those obtainable by the combination of each acid with each base; and by varying the relative masses of the acids and bases in certain ways, one pair of salts can be made to predominate over the complementary pair under one set of conditions, and *vice versa* under other conditions. For example, we find that if a soda soap be dissolved in water, and a large quantity of potassium chloride added to the solution, it is possible to convert considerably more than half of the soda soap into potash soap, with formation of the corresponding quantity of sodium chloride, out of the four compounds, (1) potash soap, (2) soda soap, (3) potassium chloride, and (4) sodium chloride. Under these conditions, 1 and 4 are formed to a larger extent than 2 and 3, so far as the fatty acids and soda are concerned; while, if a potash soap be similarly treated with sodium chloride, the same four salts will result, only now 2 and 3 will be formed to a greater extent than 1 and 4, so far as the fatty acids and potash are concerned; the difference in the two cases being essentially due to the fact that, in the first instance, a relatively large mass in excess of 3 is present, and in the second a similar excess of 4.

In a similar way, if a potash soap be well intermixed in a molten condition with a solution of carbonate of soda, and if, in a parallel experiment, a soda soap be intermixed with carbonate of potash, in each case four compounds will result, viz., (1) potash soap, (2) soda soap, (3) carbonate of potash, and (4) carbonate of soda; the relative proportions in which the two alkalies are associated with fatty acids depending on the mass and nature of the alkaline carbonate present. In this instance, however, the displacement of potash from combination with fatty acids by soda always takes place less readily, and that of soda from combination with fatty acids by potash more readily, than is the case when alkaline chlorides are used as above instead of carbonates.

It is remarkable that when there are two alkalies present (potash and soda) in the caustic state (*i. e.*, as hydroxides), and no acid except the fatty acids of soap, there is no marked preferential combination of either alkali with the fatty acids as compared with the other. Thus we find that all the ordinary fatty acids, when treated with a mixture of caustic potash and caustic soda in equivalent proportions, and in quantity jointly equal to twice the amount capable of combining with the fatty acids, appear (according to our experiments) to form a mixture of potash and soda soaps, containing sensibly half the fatty acid in combination with the one alkali and half with the other, while the un-

* In all probability, hard soaps were first manufactured in this way, the use of wood ashes and fatty matters for making potash soaps of a crude character being, as above stated, the earliest traceable kind of soap manufacture.

† In the same kind of way, when nitrate of soda and carbonate of potash are brought together in solution, nitrate of potash and carbonate of soda are formed, nitric acid being a stronger acid than carbonic acid; this reaction has long been utilized as a means of manufacturing saltpeter from the cheaper nitrate of soda.

combined alkaline lye similarly contains equivalent quantities of each alkali.*

It may be added that our experiments have also been continued in the direction of the examination of ammonia soaps and salts and their reactions respectively on the salts and soaps of the fixed alkalies; with results of interest from the point of view of the study of the modes of partition and combination of pairs of acids and bases respectively when present together, and the influence thereon of circumstances. Thus it may be noticed that if an aqueous solution of an ammonia soap be prepared (by neutralizing a fatty acid with a slight excess of ammonia solution and dissolving in water without the application of heat), and chloride of potassium or sodium be added thereto in quantity, chloride of ammonium is largely formed, and a soap thrown out of solution in the briny fluid which contains the great majority of the fatty acid combined with fixed alkali equivalent to the chloride of ammonia produced; but, on the other hand, if a potash or soda soap be similarly dissolved in water, and chloride of ammonium in large quantity be added to the solution, the great majority of the fatty acid goes out of combination with the fixed alkali, which becomes almost wholly transformed into chloride, while an ammonia soap is the complementary product first formed (usually more or less completely broken up into free ammonia and an acid ammonia soap by a secondary reaction).

APPARATUS FOR PACKING FLOUR IN BAGS.

THE accompanying engravings illustrate an apparatus devised by Mr. Koellner for packing flour or bran in bags. The ground material comes through a chute, F, that runs from the floor above, passes into a cylinder, C, and is compressed therein, by means of a helix, H, into the bag, S. As shown in the figure, the bag is fixed to a ring, O, which is guided along the cylinder and supported by chains that run over pulleys, *m*. Upon the axle of these latter there is a wheel, R, whose motion is regulated by a brake, Φ, connected with a lever, L. A counterpoise, Q, movable upon the latter, is shifted by means of a cord, *s*, in measure as the bag descends. With this system the brake offers slight resistance when the bag is empty, in its initial position, but is locked when the bag is full. In this case, a chain, *j*, attached to a ring, O, tautens and exerts its action upon the lever, *h*, which slips the belt on to the loose pulley, *p'*.

The counterpoise, Q, is designed for automatically raising the empty bags to their initial position.

The vertical shaft, A, which is moved by the pulley, *p*, and conical gearings, runs in bearings, *k k'*, only the upper one of which is lubricated.

This very simple machine has given excellent results wherever it has been applied. One workman can operate two machines at once, thus much reducing the labor; and it has been found possible to fill by this means 70 or 80 110 pound bags of bran per hour.

The pressure, which is limited and regulated by the movable counterpoise, permits of increasing the contents of the bags by 50 per cent. without tearing them. Thus the consumption and repair of bags is reduced, as is also the space occupied in store and wagon.—*Annales Industrielles.*

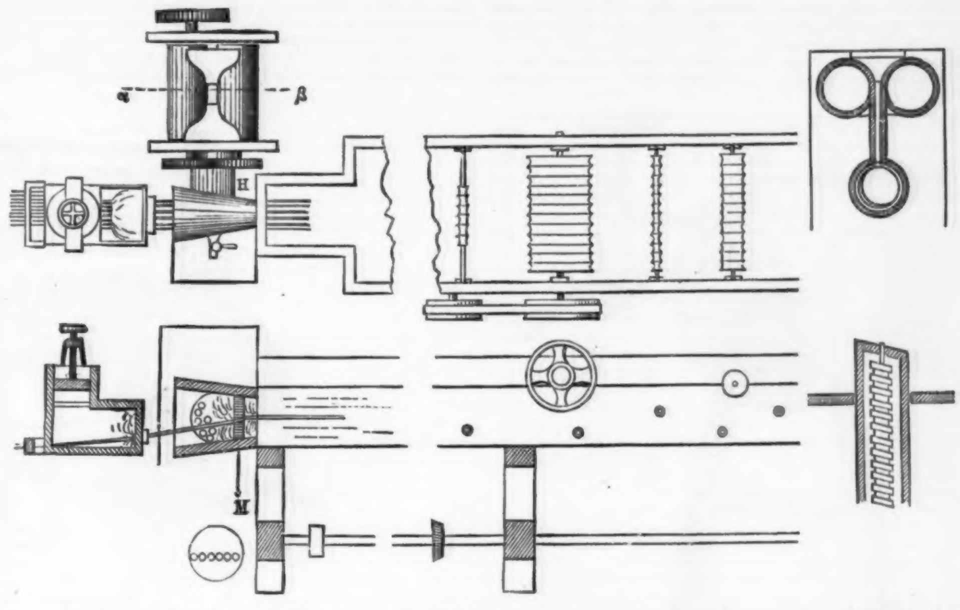
* The experimental data on which these conclusions are based, and the results of various other analogous experiments, are hardly suitable for discussion on the present occasion; their description is therefore deferred until a convenient opportunity of communicating them to another society occurs.

MACHINE FOR COVERING COPPER CABLES WITH GUTTA PERCHA.

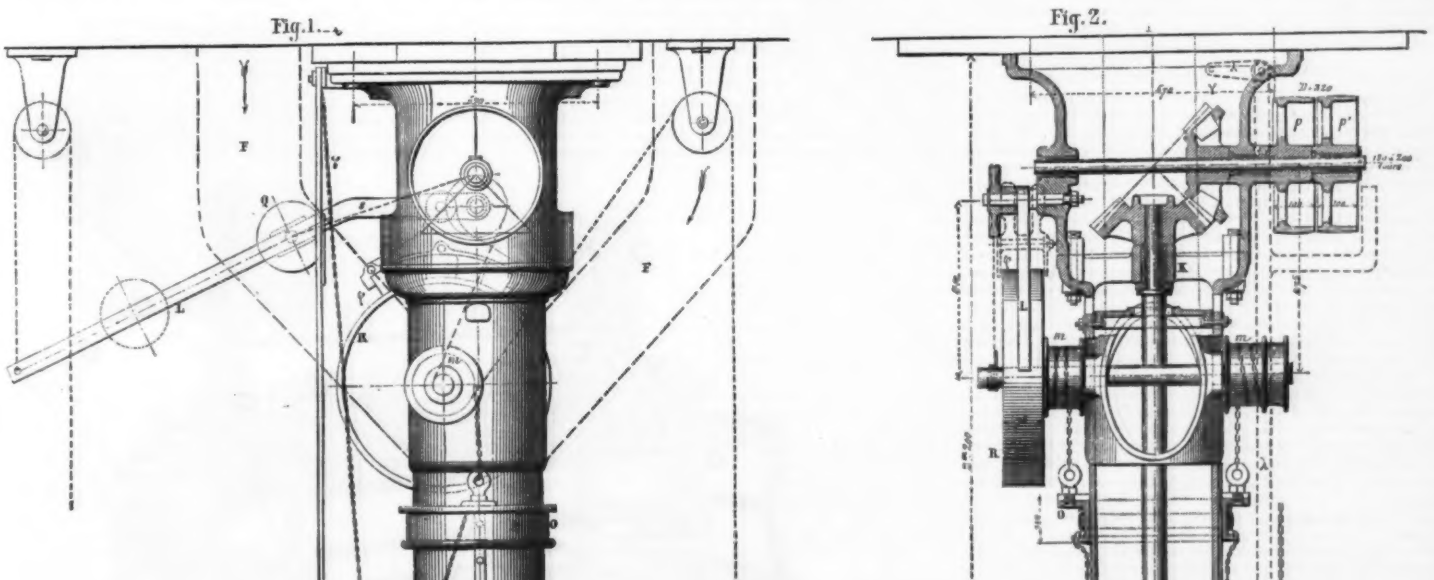
THE accompanying figure gives the details of one of the machines that are at present used for covering copper cables with gutta percha. After the cable has been formed, it first receives a coating of Chatterton composition* by being passed through two boxes in which the material is kept in a semi-fluid state. On making its exit from each box, a fixed piece, forming a gauge, removes the excess of material and makes the remaining coating regular. From the Chatterton boxes the wire directly enters the covering machine, which consists of a series of nozzles, the center of which is occupied by the wire, and through which the material is forced under strong pressure. Two cylinders, one revolving toward the other, receive the gutta percha and carry it along, in the form of a very compact ribbon, to a horizontal cylinder containing an endless screw. The bottom of this cylinder consists of a disk having numerous apertures. The material, held between the screw and the side of the cylinder, is carried along and forced through the apertures in the form of very compact threads, which escape into a chamber in the shape of a truncated cone, through the wide end of which enter the composition-coated wires, and in the narrow end of which is fixed the perforated disk or draw-plate. Here, constantly thrust by the gutta percha, which is flowing from the screw cylinder, they follow the motion of the wires, become compacter and compacter in measure as the chamber gets narrower, and finally enter the draw-plate and become moulded into a very compact and homogeneous cylindrical mass. In order that these operations may be more easily effected, all parts of the apparatus are surrounded with steam jackets so as to keep the gutta percha hot. On another hand, as it is well to cool the gutta percha as quickly as possible after its exit from the apparatus, in order to prevent the wires from getting out of center, the cable is made to enter a bath of cold water as soon as it comes from the cone. In order to prevent a contact of the water with the metallic parts, and the cooling that would result from it, the draw-plate is embedded in a mass of cement that presents a series of corresponding apertures. The different parts of the machine are so actuated that the velocity with which the wire escapes may be modified at will. The greater the mass of gutta percha, the slower the motion. On an average, the velocity is 40 feet a minute.

As necessary accessories, these machines are provided with long troughs full of cold water, in which the still soft gutta percha assumes the necessary form, and a system of bobbins upon which the cable winds. The time necessary for cooling varies with the bulk of the material, and is consequently longer for the second or third coat than for the first. In order to do away with the necessity of very long troughs, the wire is made to take several circuits over small pulleys whose channels are faced with gutta percha. The wire travels through 490 feet of cold water at the first coating, and through 900 at the second and third.—*Le Genie Civil.*

* Formed of gutta percha 3 parts, resin 1 part, and Norway tar 1 part.



MACHINE FOR COATING COPPER CABLES WITH GUTTA PERCHA.

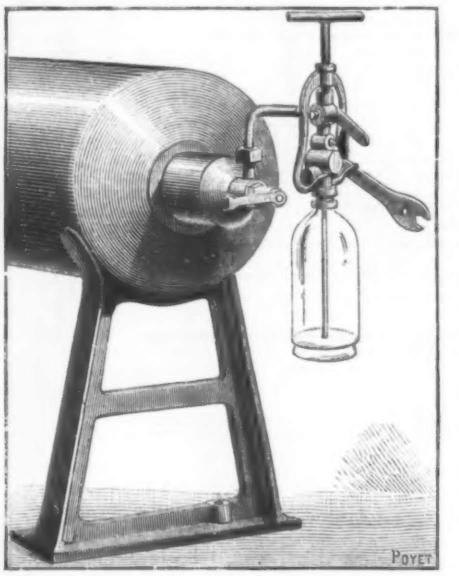


LATERAL ELEVATION. VERTICAL SECTION.

MACHINE FOR PACKING FLOUR IN BAGS.

APPARATUS FOR FILLING SIPHONS WITH LIQUEFIED SULPHUROUS ACID.

THE numerous experiments in disinfecting with sulphurous anhydride have shown that the chief difficulty in the way of the various applications of it reside in the imperfection of the apparatus designed for holding and distributing this liquefied gas under strong pressure. As this agent is called upon to render great services in a host of cases in which the sulphurous acid produced by the direct combustion of sulphur, and without pressure, cannot be used, it is of importance to prevent to as great a degree as possible any leakage, and to be able under all circumstances to easily bottle, carry, handle, and apply this powerful disinfectant. After many experiments, Dr. Victor Fatio, of Geneva, has succeeded in constructing for this purpose an apparatus that permits of quickly and safely charging siphons from the fountains in which the anhydrous sulphurous acid is delivered to consumers.



APPARATUS FOR FILLING SIPHONS WITH SULPHUROUS ACID.

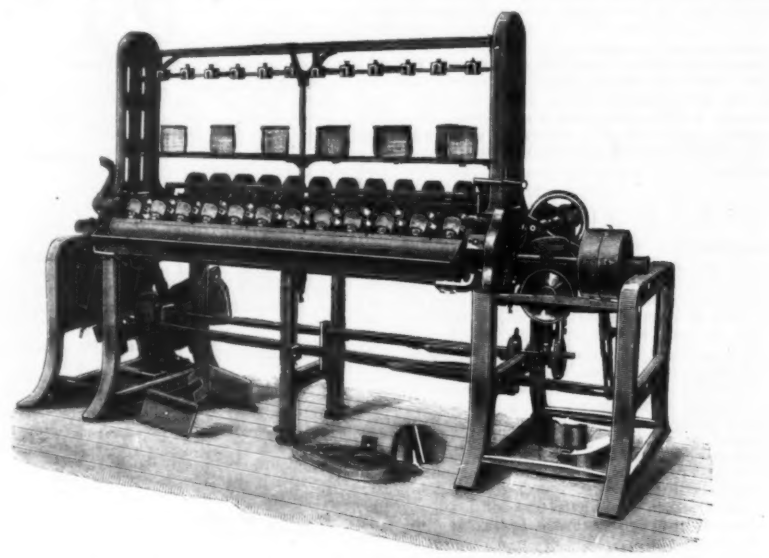
The annexed figure shows one of the siphon apparatus being charged with sulphurous acid from one of Mr. Pictet's metallic fountains. The specially arranged siphon is provided at the upper part with a tube by means of which it is put in communication with the fountain through a bent tube. To the siphon there is adapted a key which permits of opening and closing it before and after the introduction of the liquefied gas. Another key is fitted to the fountain. At the upper part of the device, which rises when the siphon is full, there is a handle for tightening it up. For disinfecting a room by means of a siphon of sulphurous acid, it suffices to empty some of the liquid into a basin and allow it to evaporate. By means of a rubber tube running through a hole in the door or wall, a room may be disinfected from a siphon placed outside.—*La Nature.*

IMPROVED BALLING MACHINE.

THIS machine is the patent of the eminent firm of sewing cotton manufacturers, J. and P. Coates, Ferguslie, Paisley, having been designed by Mr. Thomas Watson, one of their employes, to make twelve balls of crochet cotton simultaneously. The balls can be made of any size and to contain any length of thread. They can be made either upon a thin paper tube or without any tube at all. Up to the present, balling machines have been made to work with pulleys, driven either by straps or bands. As might naturally be expected in this arrangement, there has of necessity been more or less slipping of the bands and straps, which has resulted in unequal quantities of yarn upon the balls. It could never, therefore, be guaranteed that balls of a specified length actually contained the quantity stated. Again, the balling machines in general use do not, in several of their motions, act automatically or with the accuracy desirable, the consequence being that no assurance can be given that the result of their working will be uniform. For a long time, therefore, there has been a demand for a machine to make balls of any length which could be guaranteed to contain the specified quantity. The machine under notice supplies this requirement. It is automatic throughout, being driven positively by gearing in such a way that, whatever length of yarn is required, the machine can be set to give that length accurately and with certainty. Our illustration shows a machine designed to wind twelve balls at a time, of from 30 yards to 1,600 yards, or even more; there is, indeed, no limit to the length of yarn that can be put in a ball. The machine derives its motion from a shaft running through the center of the frame. On this shaft are placed fast and loose pulleys in the ordinary way driven by a strap. Upon the shaft are also placed skew spurwheels working at right angles, and conveying the driving for the various motions. Upon the same shaft are also fixed as many pairs of such skew spurwheels as there are balls to be made on the machine.

The spindle is a compound one, and has been patented. The outer spindle carries a disk, and is driven positively by the skew spurwheels. The inner one fits inside the preceding one and carries a flier, driven by friction, which derives its motion from the pressure of a drag cloth against the disk. This drag cloth inserted into one leg of the flier is a patented arrangement. It can be regulated with the greatest nicety to give any required pressure, so as to build up the ball either hard or soft. Every ball can thus be produced of any required size and with great exactitude, which is a matter of importance, as the boxes in which balls are packed are made in large quantities, and consequently an important requirement is that the balls should exactly fit them. Another piece of mechanism actuates an oscillating box, containing the spindles upon which the balls are wound. These spindles are made to revolve automatically, and at a variable speed; the oscillating box has also an upward and downward movement, being actuated by a quadrant which varies its position continually in such a manner as to imitate the motion of winding balls by hand, making the balls hold together firmly, and placing the layers in an even plat or crossing fine or coarse, as may be required.

Another arrangement actuates the measuring motion described below, so as to give the required length in each ball. This motion is worked by a shaft running lengthways, upon which are placed drums exactly one yard in circumference, one drum to each ball. Upon the same shaft are a pair of bevel wheels, working an upright shaft, at the bottom of which are placed a worm, and, gearing into it, a worm wheel, the latter containing as many teeth as the number of yards to be wound in each ball. Each revolution of the measuring drum working the bevel wheels moves the worm wheel at the bottom of the shaft one tooth, so that every tooth in this wheel gives one yard of yarn, and therefore the total number of teeth corresponds with the length in yards of the ball. The shaft upon which the above mentioned worm wheel is placed carries at its opposite end a tappet, working a lever, which comes into operation when the worm wheel has made one revolution, and stops the frame, so that whatever length of ball is being made, the tappet stops the frame when the required number of yards has been wound.



THE FERGUSLIE BALLING MACHINE—FRONT VIEW.

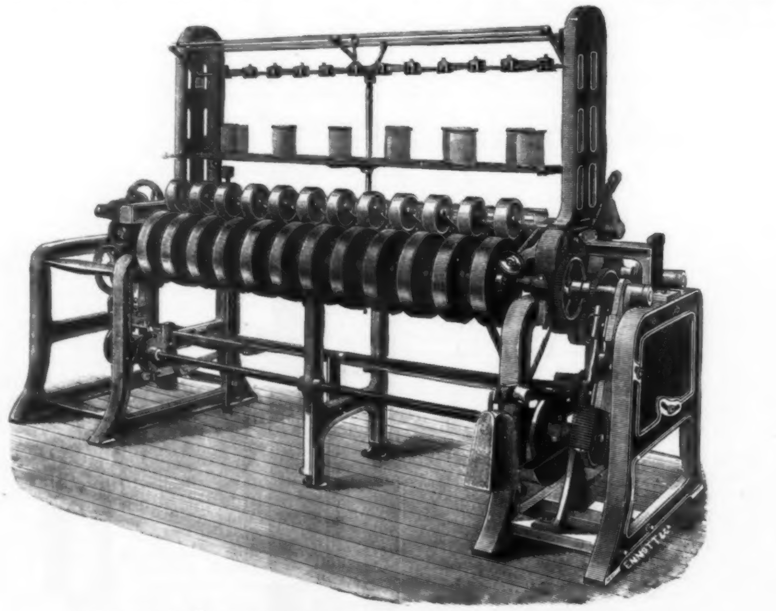
The plat of the ball can be varied as may be desired, provision being made for this in the construction of the machine, by the changing of a wheel which alters the plat, making it finer or coarser as desired.

The yarn passes from the large bobbins placed in the creel over a polished iron rod, through a circular ring, and down to a friction pulley covered with rubber, passing round this pulley (which rests upon the measuring drum), and is then carried forward through the positively driven spindle; it is then threaded through the leg of the flier, from which it passes on to the balling spindle, on which the ball is formed, the drag flier above described taking up the yarn at the speed at which it is delivered by the measuring drum.

The rubber covered friction pulley is pressed in close contact with the measuring drum by steel springs, and has a traverse motion attachment for preventing the rubber being cut through. The pressure referred to prevents any possibility of the yarn slipping, and at the same time the rubber does not flatten or injure the yarn. The tappet for stopping the machine when the ball is made can be arranged to stop as often as may be required during the making of the ball, for the purposes of ticketing, putting on trade marks, etc. In the event of balls of exceptional length being required, an additional motion is provided for the purpose. The upright shaft above described is taken out of contact with the measuring drum shaft, and an independent mechanism is brought into gear, by which balls of any length can be produced.

The production of this machine is enormous, as it will wind on each spindle 250 yards per minute, or say 3,000 yards per minute from a frame of 12 spindles, which is the most convenient size of machine. In actual working so great is the production that more hands are required to carry away and pack the balls than to work the machines. The chief advantages of the machine may be summarized thus: (1) It will make the greatest range of balls; (2) each ball contains a positive length of yarn; (3) the balls are uniform in size; (4) a ball of a given length can be made either large or small; (5) the machine is easier to mind than any other balling machine, and all the motions being automatic, positive in action, and worked by mechanism, a complete ball is made without any assistance whatever, all the work the attendant having to do being to supply the creel bobbins to the machine, and take off the balls when made; (6) the amount of waste is greatly reduced, and is less than that made by any other machine; (7) a very much greater production is obtained from it than can be got from any other machine; and (8) the quickness with which it can be changed from one length of ball to another. This is done in a few minutes, whereas in other machines it takes two to three hours. There are numerous other advantages which we could enumerate, but the above will show that the machine will be a great boon to firms engaged in making cotton balls.

The maker is Samuel Brooks, Union Ironworks, West Gorton, Manchester. One of the machines can be seen at work in the International Inventions Exhibition.—*Textile Manufacturer.*



THE FERGUSLIE BALLING MACHINE—BACK VIEW.

NITRO-CELLULOSES.

CH. E. GUIGNET, the author, is of opinion that guncotton prepared at high temperatures and used as an explosive represents almost pure deca-nitro-cellulose. The gun-cotton prepared for collodion with a mixture of sulphuric acid and niter constantly contains sulphuric acid and potassium in a special organic combination. This product, possibly, does not represent a pure chemical species. The author has not succeeded in preparing Sutton's alcolene, described as being entirely soluble in alcohol. He admits four distinct nitrocelluloses, each of which may be regarded as cellulose in which, respectively, four, six, eight, or ten mols. of water are replaced by the same number of mols. of

hydrated nitric acid. The nitro-celluloses are, therefore, true compound ethers formed from cellulose. In contact with powerful bases it ought to yield nitrates and reproduce cellulose, but the reactions are far more complex, and vary with the conditions of the experiment. In contact with an alcoholic solution of potassa, gun-cotton turns brown and is heated to the point of explosion. Gun-cotton is slowly attacked by ammoniacal alcohol, partially dissolving in the course of a few days. The undissolved portion consists of short fibers, slightly curved, and simulating crystals. The aspect of this material is absolutely different from that of the original gun-cotton as seen under the microscope.

NEW METHOD OF MANUFACTURING INCANDESCENT LAMPS.

A NEW process of forming a vacuum in glass globes for incandescent lamps has just been patented in Germany by Mr. Wellstein, of Berlin. This process will

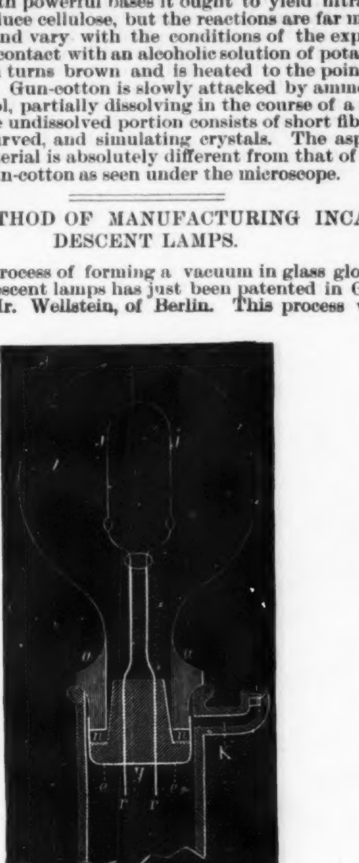


FIG. 1

permit of the same globe being used again after the carbon has been used up.

The glass globe, A, which is open beneath, is placed, with a hermetic collar, upon an air-pump, after the plug, *g*, has been introduced. This plug, which is traversed by the carbon, *j j*, is provided with a lining of rubber or some other insulating material. An elastic band, *e e*, tends to draw the plug into the neck of the globe. At the moment the air is exhausted the plug is squeezed hermetically against *a a* through atmospheric pressure.

In order to prevent the entrance of the external air into the globe, the inventor recommends that a thin layer of disoxygenated cement be spread around the surface of the lining. The apparatus for producing a vacuum is parallel above with a bent tube, *k*, which carries a valve or some analogous arrangement.

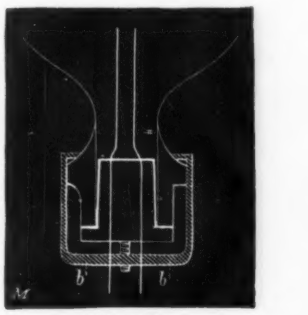


FIG. 2.

In order to render the fastening secure, the plug may be held by a clamp or screw (Fig. 2).—*La Lumiere Electrique.*

JAPANESE TATTOOING.

THE last number (Heft 32, May, 1885) of the *Mittheilungen der deutschen Gesellschaft für Natur- und Völkerkunde Ostasiens* is almost wholly occupied by a paper of a most exhaustive character by Dr. Baelz, a physician in the service of the Japanese Government, on the physical qualities of the Japanese. A previous paper by the same writer gave the results of his investigations into Japanese skeletons. For the purposes of the present paper he obtained numerous anthropometrical measurements—about 2,500—based on a scheme which included seventy-nine measurements in the case of each individual. It is noticeable that Broca confined himself to little more than a third of this number, Virchow's scheme contemplated thirteen and at the most thirty-eight, Weissbach sixty-seven, and Quetelet, in his anthropometry, gives eighty-two measurements. The skeleton plan of the paper is as follows: 1. Skin and hair; the color of the skin and its cause, artificial coloring, including tattooing, the characteristics and nature of the hair. 2. The *physique* in general, including the carriage and gait of both sexes, weight, size, and growth. 3. Measurements of the body and limbs. In the discussion of the results set forth in this section, the author expresses the opinion, based on his own investigations, that in general the value of these anthropometrical measurements is much exaggerated by anthropologists and ethnographers.

The tattooing of the skin by Japanese, generally those of the lower classes, has attracted much observation from Europeans, due partly to the extraordinary elaboration and artistic skill displayed, partly to the fact that the occupations and customs of the class in which tattooing is most practiced are such as to render it necessary frequently to wear none but the most indispensable garments. This subject has never, so far as we are aware, been examined with so much thoroughness and care as by Dr. Baelz. He says that among the various peoples which have, in the course of centuries, reached a high standard of culture, the Japanese are probably the only race which have retained generally the practice of tattooing, and have brought it to a state of highly artistic development. Up to a few years ago the practice was so widespread that in Tokio alone there are estimated to have been, possibly still are, 30,000 men who were tattooed. This decoration is not confined, as in Western countries, to a small part of the body, but it covers the whole back and a considerable part of the limbs. The head, neck, hands, and feet are never tattooed, a circumstance of importance in explaining the practice. It was confined to the lower classes; among the better classes it was considered unworthy to disfigure the body in this way. It was widely spread among the workmen in great towns, and coolies, and even to-day it is exceptional to find an old man of either of these occupations who is not tattooed. The objects illustrated were various; among the most common were large dragons, lions, battle scenes, beautiful women, historical occurrences, flowers, etc. Dr. Baelz states that he never saw obscene pictures tattooed. The colors employed are black, which appear blue, and various shades of red. The first is obtained from Indian ink, the usual Japanese writing material, the red from cinnabar.

When a man wishes to undergo the process, he looks out in a popular picture-book some illustration which takes his fancy, or he evolves something from his own imagination, and goes with it to the artist. The latter makes his arrangements, and sketches the picture on the skin. If he is skillful at his calling, he sketches the merest outline, and straightway introduces all the détails; but if he is not so confident in himself, he first draws the whole picture on the skin. There is no special ceremony attending the work as in some of the South Sea Islands, nor is there any religious signification whatever in the process. The artist uses for the purpose exceedingly fine, sharp sewing needles, fixed firmly, four, eight, twelve, twenty, or forty together, in a piece of wood. They are arranged in several rows; when there are forty, they stand in four rows of ten each. The points are quite even, except when it is desired to produce a light or dark shading, when the needles are arranged in corresponding lengths. This combination is said to be especially painful. The skin, at the place where the puncturing is going on, is stretched between the thumb and first finger of the operator, who holds between the third and fourth fingers of the same hand a writing brush with ink or cinnabar, as may be required, on it. He holds the wood containing the needles in his right hand, and, having put the color on them, he rests the hand on the thumb of his left hand, and then proceeds with extraordinary rapidity to puncture the skin, stopping every now and again to put on the fluid anew. Dr. Baelz counted on one occasion ten punctures per second, and as there were ten needles, the person being tattooed received one hundred punctures per second. The wonder is that with such speed excellent pictures, with various degrees of shading, can be produced, but such is the fact.

A skillful operator can in this way puncture the back or breast and stomach of a grown man in a day. A few hundred thousand punctures are necessary for this purpose. The patient, if he may be so styled, does not suffer so much pain as might be expected. The punctures are not very painful; they tickle rather than hurt. No blood is drawn; a circumstance which shows that the needles do not reach the cuticle, and which also explains the slight pain of the operation and the possibility of enduring it. This, however, is not the case always, for in many parts of the body where the skin is tender, or where a deeper shade is required, some clammy blood comes slowly to the surface, and the operation becomes painful. This occurs most frequently at the knees and elbows. To be well tattooed, therefore, is taken as a sign of manly vigor and endurance. As soon as the sitting is over, the punctured parts are bathed with warm water, which produces a slight pain. The color then comes out more clearly than before, and the patient can do as he likes. No special diet is ordered. A few hours after the operation he often has a slight feverish feeling, but this soon leaves him. After about three days the skin scales off like bran, but the tattooed parts are never irritable or sensitive, and the man goes about his work as usual.

There are cases in which women have been tattooed, but these are very rare. The women are mostly dissolute who allow this to be done; but it is said that the colors come out with great clearness and beauty on the comparatively fair skins of women. Recently tattooing has been prohibited by law, under the impression that it is a barbarous custom, unworthy of a civilized people. But Japanese tattooing is so superior to that of all other nations that European sailors are said to look forward to it as the principal advantage in a visit to the land of the Rising Sun.

This being the method in which the practice is carried out, Dr. Baelz comes to discuss its origin and meaning. The oldest reference we have to tattooing in Eastern Asia states that a Chinese prince, about three thousand years ago, who was nominated heir to the throne against his will, had himself tattooed in order to render his succession impossible. But at the present day the practice in China and Korea has fallen into desuetude, while in Burmah it still appears to be in vogue. In 1872, a man was exhibited in Europe who had been a prisoner among the Burmese, and who was tattooed from the crown of the head to the sole of the foot. The practice is still prevalent among the South Sea Islanders and the American Indians. In his work on the origin of writing, Wuttke seeks to show that tattooing is a kind of writing; but however correct this theory may be in the case of the tattooed peoples known to him, it certainly does not hold good in the case of the Japanese. The signification of the practice, says Dr. Baelz, among the latter is quite distinct from that which it has among other peoples. In the first place, among the South Sea Islanders and the Indians, tattooing has a religious, a symbolical meaning; it is a ceremonial, frequently a sacred process. There is nothing of this in Japan—neither ceremony, nor other peculiar meaning; it is done for cosmetic purposes and for no other.

Again, among other peoples tattooing was a species of distinction; it marked the heroes, leaders, chiefs, of the tribe. In Japan it marks a man of the lower classes. Elsewhere, also, the uncovered parts of the body, such as the face, neck, hands, etc., are the favorite spots for tattooing; in Japan it is only the portions usually clothed which are tattooed. It is noticeable that among the Ainos the tattooing takes place on the exposed parts of the body, and that it is largely practiced by women, two circumstances which distinguish it from the practice among the Japanese, and in which the Ainos resemble other northern peoples such as the Esquimaux, the Ostiaks, and others. In answer to the question, What meaning has the practice among the Japanese, as distinct from other races? the author replies that in Japan tattooing is a garment, a decoration.

Various proofs of this statement are advanced, among them being the following: Only those parts of the body are tattooed which are usually covered; all workmen do not tattoo themselves, but exclusively those whose work causes excessive perspiration, and who can, therefore, work best in a semi-nude state, such as runners, grooms, bearers, etc., and among these the practice prevails only with those who have connection with large towns, where nudity would be objectionable. Their garments are tattooed on their bodies, and they appear clothed without clothes before the public. The peasants are never tattooed. Again, the color of the tattooing corresponds with that of the dress; it is the same dirty, dark blue. This theory never suggested itself to the Japanese; they thought that it must have come from China, and that it was a species of punishment.

It was, it is true, at one time the custom to tattoo marks into criminals, but this was confined to a ring on the elbow. It would not explain the spread of the practice among certain classes in certain directions. Dr. Baelz's theory is that it is merely a substitute for dress, and as the wearing of clothes is now compulsory, tattooing has lost its meaning. As for its origin, the peoples around the Japanese, the Ainos and the Loochooans, have practiced it; and the Japanese navigators, who traveled far and wide in the Eastern seas in the sixteenth century, might well have seen it elsewhere. The Japanese discovered, says Dr. Baelz, that man can paint a figure on his skin which the rain cannot wash away, the sun wither, or even all-devouring Time destroy, and with their instinctive artistic skill they gradually developed and perfected the original rude figures in idea and execution. At first few only wore this blue skin-dress, but these few appeared to their companions decorated and clothed (a tattooed person does not appear actually naked), and as such a garment was cheap and lasting, and every man could have it according to his own fancy, tattooing became the fashion.

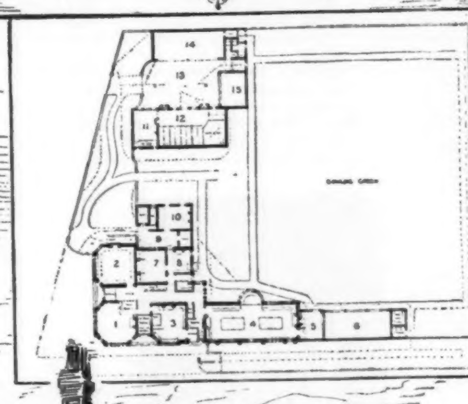
It may be added here that among the Igorrotos of the mountainous districts in the north of Luzon tattooing is also exceedingly elaborate, although it consists rather of a series of lines, curves, etc., than of one large, elaborate picture. Dr. Meier, in a paper read not long since before the Anthropological Society of Berlin, described the Igorrotos as tattooing the hands, arms, breast, and also part of the legs. The back is untouched except by one tribe. A picture of the sun, or a number of concentric circles on the back of the hand, is the commonest object represented. The process takes place at puberty, and is a long one, as the punctures (which are made with a three-pointed instrument which is clumsy in comparison with the Japanese needles) become inflamed and take a long time to heal. The tattooing of the Buriks, a tribe of Igorrotos, takes three or four months to complete.

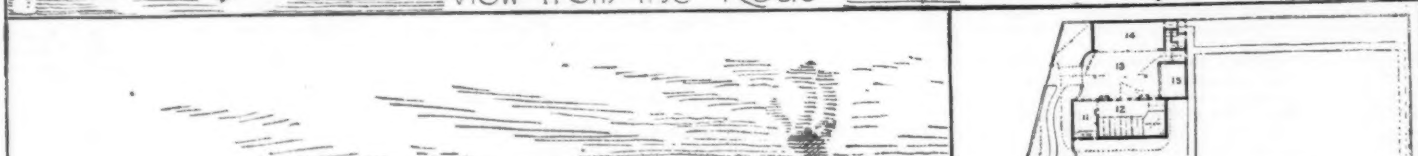
It may not be out of place here to refer to Dr. Baelz's account of the Japanese use of moxa, which, like tattooing, comes into his section dealing with the skin. On the bodies of almost every Japanese, and sometimes on every part of the body, one sees round white spots. These are the moxa spots, produced by burning the flesh with a species of plant, with the object of curing some affection. This is a universal popular specific in Japan, which is its home, although moxa is to be found used elsewhere. It was introduced from Japan to Europe by the Portuguese and Spaniards, and the name is Japanese. In May the leaves of the *Artemisia chinensis* are powdered and dried, and the mass cut into small blocks or pieces. One of these is laid on the body and set on fire, burning slowly away. At first it naturally produces a sore, more or less deep, according to the intensity of the heat; soon this heals, leaving the scar forever. The belief in the efficacy of this process is universal, and, Dr. Baelz thinks, not altogether misplaced, for the moxa acts much as our blisters do. Moreover, from the accounts of those who have gone through the cure, it is by no means so painful as one would anticipate from the heroic nature of the remedy. —*Nature.*

QUALIFICATIONS OF FOREMEN.

MR. GEO. W. STEVENS, master mechanic of the Lake Shore and Michigan Southern Railroad at Cleveland, Ohio, gives the following as his idea of what a good railroad shop foreman should be. *The Western Manufacturer* suggests that they are also what the foreman of a woodworking shop should be, and commends them to employers. "The selection should be made from the shop force, and from the class that are active, energetic, conservative, and progressive, with moral character predominating, giving preference to the oldest men if the merits are equal. In qualifications some knowledge of figures, reading, and writing is essential; being able to comprehend orders clearly and quickly; mechanical skill, executive ability, systematic and thoroughness of work, and a full knowledge of what should be done as well as how it should be done are also desirable. Too much value cannot be placed on ability to impart knowledge to others, and it should be constantly the aim of the foreman to explain clearly and direct. Many fail in this particular, and attempt to perform themselves what should be done by others. The old saying, 'As with the captain, so with the soldiers,' is especially applicable to shop foremen, and any foreman can quite accurately be judged by the performance of the men."

View from the Road





·View·from·the·Bowling·Green·

THE·MIDLAND·HOTEL·WITHINGTON· WILLIAM DAWES Arch't MANCHESTER

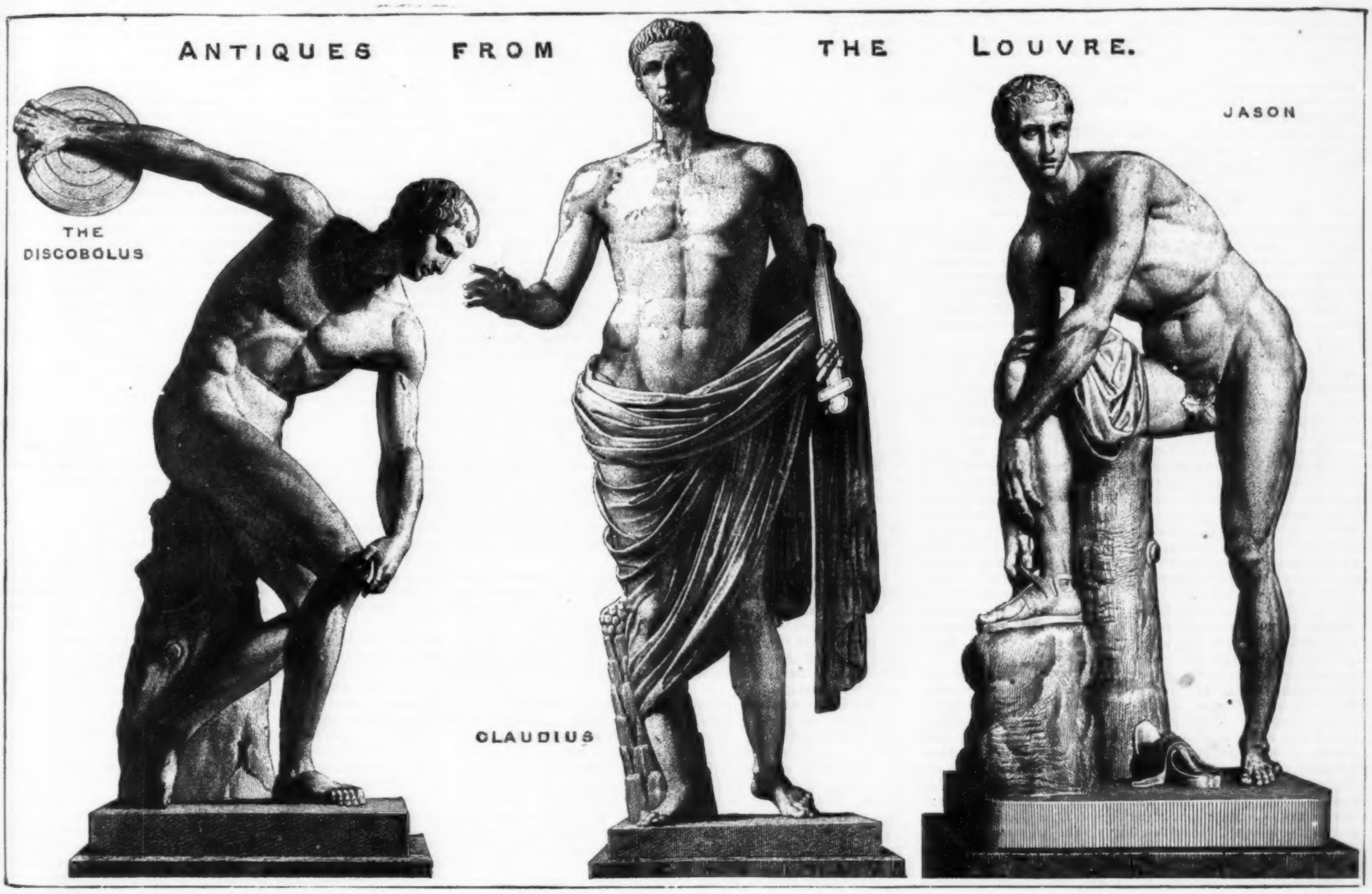
THE MIDLAND HOTEL, WITHINGTON, NEAR MANCHESTER.

THIS building has been erected from the designs of Mr. William Dawes, architect, of Manchester, and is now being extended under his superintendence. It is situated at the corner of Burton Road and Lapwing Lane, and is near the Midland Station at Withington. As will be seen from the illustration, it is designed in the half-timbered style, and is picturesque in treatment. The lower stories are built of brick with stone dressings. Adjoining the hotel are blocks of stable buildings, billiard-room, bowling-green shelters, etc. The building internally is well finished, and much good effect is produced by the introduction of tinted glass and ornamental tiling. Messrs. Southern & Sons, of Salford, were the contractors.

The following is the index to numbers on plan: 1, bar-parlor; 2, smoke-room; 3, tap-room; 4, billiard-room; 5, bar; 6, pavilion; 7, kitchen; 8, scullery; 9, yard; 10, wash-house; 11, harness-room; 12, stable; 13, stable-yard; 14, general coach-house; 15, private ditto.—*The Architect.*

ANTIQUES FROM THE LOUVRE.

THESE fine Greek and Roman sculptures are notable antiques, and furnish admirable subjects for frequent reference by the student. Good drawings of them are not often readily accessible. The Discobolus, or Thrower of the Discus, was the work of Myron, and is referred to by Ovid. The figure is shown in the moment of transition and pause between two energetic actions, when the quoit thrower has collected all his force for the highest effort in the great feat of athletic strength and skill. The face is that of a handsome Greek youth, noble and refined, but there is little expression in it. Discus throwing was one of the principal gymnastic games of the Greeks, and included in the Pentathlum. Claudius, the next figure here drawn, was Emperor of Rome, A.D. 41-54, and succeeded Caligula. His principal achievement was the triumph he obtained in South Britain, where he went in the year 43. He soon returned, leaving the conduct of the war to his generals. His fourth wife was his own niece Agrippina, who with a villainy all her own persuaded the wicked monarch to set aside his own son's claims upon him and to adopt her own son, Nero, whose name is forever associated with the most wicked of crimes. Claudius regretted this step, and was in consequence poisoned by his wife Agrippina in 54. Jason, the last of the three figures here illustrated, was the celebrated leader of the Argonauts. His voyage in the Argo to Colchis to obtain the Golden Fleece was perhaps the greatest feat recorded of him. He was aided by Juno in this enterprise. Medea, the daughter of the King of Colchis, fell in love with Jason, and, being a magician, gave him charms to protect him from danger. He afterward became enamored with Glauce, daughter of the King of Corinth, whom he married, having divorced Medea. She revenged herself by destroying her children in the presence of their father.—*Building News.*



ANTIQUES FROM THE LOUVRE.

GATTY bleaches goods containing colored yarns, such as alzarine red or indigo blue, by first scouring with soap, then passing them through a bleaching solution of 1·40 Tw., and steaming in an apparatus similar to those used by calico printers for cleaning the white of printed goods.

ON THE ORIGIN OF THE HIGHER ANIMALS.

By Prof. W. K. PARKER, F.R.S.

IN the study of living creatures, whether plants or animals, we begin with that which is superficial and familiar, and then gradually pass to the deeper and less known. For one who dissects out the structures, there are hundreds who observe the outward form and habits; and for one who studies the embryological development, there are numbers who dissect and study the structure of the various types in their adult condition. So that, although this biological field is as wide as the earth and as broad as the sea, yet there are very few who go to the bottom of things, working downward until they see the origin of a type, and then afterward coming up to tell their less adventurous fellow-workers what facts they have found in those dark depths.

In seeking to trace the origin of organisms in the modern Darwinian manner, it is always easiest and safest to pass from the familiar to the less known, and every now and then to make a stand in the ways and to see what lies about us on this side and on that, and then to choose which way we will go, what untrodden path we will try to thread our way through. Inquirers, candid and uncandid, those who pray that they may know, and those who come fully assured beforehand that they know all about the matter already—both these sorts of inquirers ask for impossibilities; they seek to have the whole matter put into a nutshell, they cannot wait for evidence in detail. Yet the evidence of these things must come in detail or not at all.

None of those who mock shall understand; but patient, and wise, and teachable minds shall be able to learn, not adequately, indeed, but in a very useful, practical, and pleasant manner. Assuredly, the best and most laborious of the biologists of this generation, and of that which has just passed away, have not been living in the region of oldwifedom, nor following cunningly devised fables. Men like Lyell, Darwin, and Robert Chambers, not to mention other great and cherished names, were of a sort not easily to be deceived. To say nothing of those in Europe, in America, and in the Isles of the Sea who are assured of the truth of the modern doctrine of development, we have here at home numbers of able men, each looking at the subject from a standpoint of his own, who have been convinced of the truth of this theory. There is indeed a marvelous consensus, or harmony, in the deductions of those who have been trained in these researches, and who are spending and being spent in this kind of work.

Those who know what it is to gather this excellent knowledge, who busy themselves in harvesting and garnering what Nature, in her lusty strength, has grown for them, without their sowing and without their tilling, are cheered on by the light and strength this theory gives them. These are they who, as botanists and zoologists, gather all that comes to hand, thus laying up in store all good things for the embryologist. In gathering and classifying and even dissecting the full-grown forms, they are only preparing the way, and filling the hands of the student of Development; yet there is nothing in the deductions they are able to make that has received or that ever will receive anything but corroboration from that slower but most important kind of work. Also those who do business in the veins of the earth, not merely near its surface, where it has been baked with frost, but deeper down—these men, who bring up the remains of old, extinct types, are ever adding to the weight of evidence in favor of this theory.

The workers of all sorts have well done what they have done, and they are a very useful and united family; but deep crieth unto deep below all that has yet been discovered, and the need for those who will go down into the very heart of things is still very great.

Now, we will suppose the candid inquirer to ask two questions; and then try to answer them according to modern lights:

1. Did the higher kinds of the vertebrata (that great sub-kingdom which is characterized by a jointed spinal column, a brain, and a spinal cord) arise suddenly, as by a creative catastrope; or by metamorphosis of the lower kinds; or slowly, during the ages, by the accretion of gentle and easy modifications, caused by the surroundings of the creature?

2. Did the lower vertebrata arise suddenly by a creative catastrophe, or by metamorphosis of still lower, non-vertebrate types—the forms so metamorphosed subsequently undergoing slow, secular changes?

I.

The first question refers, of course, to the origin of reptiles, birds, and beasts—creatures that, from the time of their hatching or their birth, breathe air, and have no gills for aquatic respiration during any period of their life. These are the higher vertebrata. Fishes (such as the lamprey, shark, and perch) and amphibia (such as salamanders, frogs, and toads) all have aquatic respiration, either permanently or for a time. These form the lower stratum of the vertebrata.

Even in their outer clothing, the three great groups of the higher stratum—reptiles, birds, and beasts—have new and strange structures, such as are not found in the types beneath them. The exquisitely folded skin of the serpent, here wrought into parallel plaits and there into diamond-shaped *tesseræ*, the plumage of the bird, and the hairy covering of the beast are all, in one sense, new things. They are adaptations to the new life on the dry land, in the open air. But you must have more than a hood if you wish for a monk, and the kind of clothing of these three groups is but the outside of what we have to deal with in biology.

The difficulty of supposing that the almost infinite variety of living creatures all arose from simpler, and still simpler and more generalized types, by a mere process of slow and gentle modifications, taking place during untold periods of time, is as great to the biologist as to one untrained in the science of life. To a certain extent, the old adage, *nihil per saltum*—nothing by leaps and starts—is true in Nature; but it is not universally true. Hence no well-informed naturalist is an absolute *uniformitarian;* he is also, more or less, a *catastrophist.* But if—leaving the great difficulty of such a problem unsolved for the present—we suppose the existing groups of higher animals to have arisen from some common, low, generalized stock, then we can easily imagine the huge results that may have taken place during long, almost unlimited, secular periods. The doubter should begin by considering, first, the close relationship of the races of one type or *species*, and then the little, non-essential things that separate or distinguish the various species of one *genus.* Thus, for example, the various races of oxen (*Bovidæ*) differ only in non-essential characters, and no one can tell where a race ends or a species begins. In this family, even the ordinary test of the fertility or non-fertility of crosses fails the naturalist altogether. Our common oxen, the bison, the aurochs, the yak, and all the different kinds of buffaloes, all go together to form

one single special group, or family, in that order of ruminants which Moses characterizes in the following words: "Every beast that parteth the hoof and cleaveth the cleft into two claws, and cheweth the cud."

Now there are in this order certain distinctions easily observed, and at the same time very useful in zoology; they are derived from the most superficial modifications, from differences that are merely skin-deep. There are ruminants with hollow horns, with solid horns, and without horns. Oxen, sheep, goats, and antelopes have a hollow, bony core, covered with a horny sheath; the core is a growth from the bone of the forehead; its horny sheath is a modification of the outer skin; these horns are permanent, and are generally possessed by both sexes. In the deer family, a large branch of solid bone grows out of the forehead on each side, carrying with it the skin, which is covered with soft hair, hence called velvet. When the bone ceases to grow, the skin dies and is rubbed off against the trees. These horns, called antlers, are soon shed, and, as a rule, exist only on the male. The musk-deer, the chevrotain, the llama, and the camel have no horns of any sort. The two last kinds, the llama and the camel, differ so much from the rest, that they form a special subdivision of the order. They are evidently very ancient types.

Again, the larger cattle, besides being divided into ruminants and non ruminants, are classified as even-toed and odd-toed beasts. The noble- and more modern types of even-toed beasts chew the cud; but there are some manifestly ancient forms still lingering on the planet which do not chew the cud, as, for instance, the hog, of which there are many species, and the hippopotamus. These, as is well known, like the more archaic ruminants, do not possess horns. All those beasts which have an even number of toes are destitute of the first or inner toe, corresponding to our thumb or great toe. In oxen the second and fifth toes are also suppressed, only the corresponding *nails* remaining as small hinder hoofs. In deer, notably in the reindeer, these hinder toes are present, but the bones are small.

As a rule, the ruminating animals have only one bone in their shank—the so-called cannon-bone; but in the early embryo, this is composed of two equal parts, each of which has a convex surface for articulation with the corresponding toe-bone; this accounts for the fact that the cannon-bone carries two toes. In the non-ruminating, even-toed animals—the hog and hippopotamus—these two bones never fuse to form a cannon-bone, but remain distinct; and this is seen in the fore legs of the African water-deer (*Hyomoschus*—a name suggesting an intermediate position between the musk-deer and the hog). This animal and its small relatives, the chevrotains of Ceylon and Java, belong to an almost extinct family of ruminants.

The hippopotamus is manifestly of an older and more general type than even the pig; he stands almost alone as the living representative of a family of gigantic even-toed beasts. In former days giants of this kind were as common as the members of the hog family are now.

None of the odd toed cattle chew the cud; only two families still exist—the several species of rhinoceros and the horse group, consisting of the horse, ass, zebra, and quagga.* The rhinoceros has three well-developed toes, each ending in a small hoof; but in the horse and his relatives only the middle toe is developed, and the bone with which this is articulated is a primarily single cannon-bone; the corresponding bone of the second and fourth digits being a mere splint, pointed below.† The rhinoceros on the one hand, and the horse on the other, are the culminating forms of the odd-toed beasts which have diverged *during time* into forms so remarkably unlike. It is very curious that these should be all we have left of the odd-toed herbivora.‡

And now the carnivorous tribes, the cat family, the dog family, and the kindred of the bears and seals, have all to be traced downward to some common stock; to say nothing of aquatic whales, aerial bats, lemurs, monkeys, apes, and men. All these, in their multitudes, come flocking for the registration of their ancestry; nor do they seal up the sum of this great and varied class, for the insectivorous kinds (moles, hedgehogs, and so forth), and the edentate tribes (the ant-eaters and pangolins with no teeth at all, and their imperfectly toothed relatives, the sloths and armadilloes), these, lowly as they are, also belong to the noble (*Eutherian*) types of the mammalia.

Down to this point we need ask for no catastrophe, no metamorphosis, nothing but time and surroundings, and the marvelous working of that indwelling force which moulds and fashions each type into a form in harmony with its outward life and conditions. All these types now mentioned belong to the highest of the three platforms § of mammalian life; all have the common characteristic that they carry their young, and do not "cast forth their sorrows" until a very considerable though varying ripeness has been attained; for a longer or shorter time they minister to the necessities of their progeny of their own substance internally, and afterward *externally*, by providing them with milk.

Before I go on to speak of the creatures on the next lower platform (the *Metatheria*), I must remind the reader that in the groups just mentioned all our zoological distinctions fail us. As we descend to the older and still older types, every landmark gets wasted away and removed, and the familiar terms that serve as distinctions in the existing fauna become utterly useless; the orders lose all order; Ruminants, Solipeds, Proboscidians, Carnivores, Rodents—all these distinctions melt away into one common, generalized, archaic group. Such a group must have contained the essence of all the present, easily distinguished orders—"all these in their pregnant causes, mixed."

For instance, in the earlier tertiary periods, we come upon large herbivorous lemurs or types that cannot well be separated from that group of four-handed creatures that lies so close beneath the primates—monkeys, apes, and men. The term "Proboscidian," again, is now restricted to a group containing only two species, the African and the Indian elephant. But that ancient kind of creature, the tapir, has a rudimentary trunk; and in former times many sorts of quadrupeds supplemented their short and stunted features by a long, two-tubed, jointed nose; nay, there still exist among the lowest noble (*Eutherian*) kinds—the insectivora—certain American and African types that have a perfect proboscis, the cartilage of the snout being divided into rings as in the elephant. That *quasi*-mouse with curious snout, the shrew, has a very long, double nose-tube, though the cartilage encircling this tube is not segmented into rings; but in the young of a species of *Rhynchocyon*, from Zanzibar—a relative of the exquisite little elephant-shrews of Africa, as large as a rat—I have made out thirty double rings.

We may, therefore, safely leave the evolution of all the high beasts (the Eutheria) to the working of ordinary influences, and no "new thing" need be created; all that is wanted is merely a recasting and remodeling of "old things" to new uses; and even the dwarfing of certain types and the gigantic development of others may be left, mentally, to the operation of forces that have worked hitherto and do still work.

But here we have to let ourselves down as dangerous a cliff as any that "he who gathers samphire, dreadful trade," ever descended. We must, if true to Darwinian principles, ask for as few interferences as possible; we expect to find no new *invention* of the Absolute Eternal Mind; for, "known unto God are all His works, from the beginning of the world." Therefore, as the author of all meets with no unexpected difficulties in the evolution of His Eternal Purpose, we may, in the patient labor of hope, expect to find all things coming up, each beautiful in his season or time, the creatures of one season being the natural descendants or children of those of the preceding.

Time was when the higher mammalia were not; and the highest quadrupeds to be found on the earth were, as geology teaches, of the same low sort as those which we now find in certain very restricted zoological provinces. I refer, of course, to the marsupials, or pouched animals, which are found at the present time in the Western Tropics, and to some slight extent in the northern part of the New World, and which in the East are restricted to a territory south of "Wallace's line"—that is to say, to the Australian region.

Of these Metatheria, or intermediate beasts, I must now speak: of their lowliness, and of their intimate relationship with the higher sorts of those creatures that lay eggs—the air-breathing ovipara, reptiles and birds. If these meaner cattle can be connected with the nobler kinds, if they can be yoked on to the others without any violence, but gently and naturally, then we shall be able to dispense with a catastrophe for the next part of our journey downward. It may be remarked, in passing, that this journey downward is not a *facilis descensus*, but is hard, panting, laborious work; the mental descent and the mental ascent are equally hard. Nevertheless, if we "gird up the loins of our mind," fearing nothing but our own impatience of imperfect evidence, we shall discover things that have been kept secret from the foundation of the world.

One of the wisest and most judicious of "those whose talk is of bullocks" (scientifically, of course, and not as a mere grazier) suggested recently to the writer that the marsupials are the *true mammalia;* milk is all in all to their children. And why? The reason of this is partly open and plain, and partly lies deep down in the nature of these remarkable creatures; this shall now be explained.

There are various degrees of ripeness of the young at the time of birth; some, like the foal and calf, are strong-limbed and active, with their special senses perfect, while others, like the pup and kitten, are blind and helpless. This difference may occur in species of the same genus. The new born rabbit is feeble and blind; the leveret is wide-awake and active from the first. In the bird class, we have whole groups, like the perching and climbing tribes—songsters, woodpeckers, and so forth—whose young are hatched in a tender state, and require great parental care; while in other birds—fowls, geese, rails, plovers, and the like—the young are strong and active as soon as they are hatched; and in the gull, they are in an intermediate condition. It may be noticed that, both in the mammal and the bird, the highest social conditions are developed in those cases when the young are born in a helpless condition. Now, in the marsupial animals the young are born, so to speak, prematurely, so that the little kangaroo, whose mother is the size of a sheep, is not so large as a new-born Norway rat; and although the mother still ministers to her young of her own substance, this is not done in the same manner as in the higher tribes, where, for many months, in some cases, the progeny and the parent are as much one organism, physiologically, as the fruit-tree with its ripening fruit. Here, among the marsupials, the germ develops itself by its own individuated morphological force, and then hastens to assume an independent life—but only partially independent, for it must now live on its mother's charity, and for many months she feeds it on milk sweet as charity.

Yet, there is no difference in all these various family arrangements that cannot be accounted for as resulting from the influence of surroundings, and the magnetic response of the organism to those surroundings.

Here, then, we are brought to reflect upon the lowness of these pouched animals, which (although even they are not the lowest of all mammalia) are almost *oviparous*, and upon their relation to the truly oviparous types, monotremes, reptiles, and birds. In reptiles and birds, the developing germ, as is well known, is wrapped in an exquisite drapery of membranes, and has, suspended from its own body, a large store of rich food-yolk, an oleo-albuminous emulsion, fit nourishment for the tender, unhatched young. The marsupial embryo—opossum or kangaroo—has also these fine, gauzy foldings wrapped about it; but they are all small, because of its early birth; and thus the food-yolk is soon used up, and there soon arises the necessity for a fresh supply of nourishment. In the nobler animals the supply of food-yolk is again much smaller than in the marsupials, and the new supply is obtained by a regrafting of the individuated germ on to the living inner walls of the parent, until the fullness of time comes for the new creature to take on a separate existence.

These instances show us that the ordinances of Nature—which are wonderful in counsel, and excellent in working—accomplished the maturation of the new individual in two very different ways, in the quadrupeds on the one hand, and the bird on the other. In the bird the food grows from, and is part of, the germ, which merely asks for the patient attendance of the nursing mother, for the sake of due warmth, until the chick is ready for hatching. In the nobler kinds of quadrupeds, where the germ itself is so poor in substance, Nature herself broods over the young. But in this ancient and lowly order of mammals, the marsupials, there is a condition of embryonic development which is, in some respects, below that seen even in the existing reptiles and birds, most of which are evidently modern types.

But if the humble marsupial thus runs down, in some of his characters, from his mammalian platform toward the non-mammalian vertebrata, his great relations, the higher mammalia, still cannot cast him off. They, some of them, bear in their bodies, even now, the traces of their relationship to him. In that remarkable insectivore, already spoken of, the rhynchocyon of Zanzibar—himself a low Eutherian—considerable tracts of the base of the skull are so unchanged from the marsupial type of structure that these parts, in fragments, could not be told from the corresponding parts in the skull of a phalanger or opossum. I have no doubt that many of the earlier tertiary cattle, whose remains are being brought to light daily, and in rich profusion, would be found, if they could be thoroughly worked out, to have skulls in which the characters of the marsupials are inextricably mixed with such as are diagnostic of the nobler forms. Hence, in the study of these ancient types the zoologists find that all their neat systems fall to pieces like a house of cards. The mere classifier, who only knows the new, high, special types, is put to confusion, for not only has the ruthless palæontologist removed the old landmarks of the higher territory, but he has also broken the hedge that kept the Metatheria from the Eutheria, the low cattle from the high.

Again, in the secluded, lowly group of the marsupials the dog is typified and foreshadowed in the most wonderful manner; the thylacine, or dog-opossum, has made the most remarkable advances dogward. The wonder grows when the two types are carefully compared, so much alike are they in outward form, and, for the matter of that, in internal structure also. Yet the gulf between these two types—anatomically, in the whole structure of these beasts through and through—is almost incalculably greater than that between a dark, human savage and a black, brutal gorilla.

Not that this remarkable anticipation of the nobler mammalia, to be seen in the ignoble marsupial group, is at all unique; it is quite similar to the range of forms to be seen in the tailless amphibia (frogs and toads), which get very high up, considering their low origin, but still lie a long way down below the true reptiles. Facts of this class are very numerous; for when any particular group is arrested at a low level, and yet can go in and out and find pasture, so as to be able to increase and multiply upon the earth, then secondary, adaptative modifications are sure to arise. Thus the group becomes subdivided into various tribes and families, some of which in their intense specialization must become very unlike the general ancestral form.*

Now, having got thus far in our descent, which is not *easy*, but is a dangerous kind of scrambling downward, we have received no sudden shock—no Cerberus has barked at us. But let me not be misunderstood. I have not been asserting that no *lesser* sudden changes have taken place. There must have been many such in the evolution of a high and noble beast from a low, ignoble, ancient marsupial, a creature very much lower than a common rat. But any gardener could show you changes, apparently sudden, in numbers of the commonest cultivated plants, quite equal to anything that need from time to time have taken place in the slow, secular uprise of the nobler beasts of the field.

After this pause, we may recommence our descent; and, if we are cautious, we need not fear. We have got safely down from the highest to the second mammalian platform—from the Eutheria to the Metatheria; we have now to let ourselves down from the second platform to the lowest—from the Metatheria to the Prototheria.

Down a long way below the marsupial group lies that which is termed the Monotremata—hairy, *oviparous* creatures, much of whose structure is only on a level with that of an ancient kind of bird or reptile. This family has lost all its members but four or five; and these belong to only two generic types, *Echidna* and *Ornithorhynchus*. The former of these is the so-called "spiny ant-eater," of which there are three or four kinds; the latter is the duck-billed platypus, or great water mole. These are all shut up in the Australian region (Australia and New Guinea), nor have any fossil remains of them been found in any other zoological region, nor yet any of importance even in the Australian, though Sir Richard Owen has described some remains of a larger kind of *Echidna* than any now existing. Fossil mammalia belonging to the highest group (Eutheria) are found in large abundance in many regions, but we are much poorer in fossil specimens of the next division—the Metatheria or marsupials; and in the case of the monotremes or prototheria, it is a great disappointment and sorrow to the biologist that Nature has so effectually covered her slain. At present, therefore, we can merely study the structure and development of these stray living remnants of an old mammalian fauna; we have to work them out and compare them with other types of vertebrated animals, both above and below them, and then to make a cautious use of our imagination.

The marsupials, when they conquered the monotremes and possessed their cities, little thought that, *in a few millions of years*, a nation greater and mightier than they would appear, multiply exceedingly, and dispossess them in their turn. Some of these marsupials, in

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* Naturalists, as a rule, include the tapirs among the odd-toed beasts. In reality they are a much more archaic group than the rest. They possess a well-developed fifth digit on their fore-foot; only the *first* being suppressed.

† Thus we see the remarkable difference in formation between the foot of a cow and that of a horse.

‡ Among the herbivorous tribes just mentioned no place has been found for the huge elephant, no place for the little hyrax (dayman or coney of the Bible); for these lie far off from the other cattle, and their kindred must be sought among the root-stocks of old and generalized types, from which sprang the forefathers of the existing rodents—the rat, squirrel, beaver, etc.

§ *Eutheria* (literally, "noble beasts"), *Metatheria*, *Prototheria*—the *Eutheria* being the placental mammals; the *Metatheria* the pouched animals, or marsupials; and the *Prototheria* those existing links which connect the mammalian group at its lower extremity with birds and reptiles.

* One word more about the marsupials. The Australian kinds, varying from the heavy, stupid, *cavy-like* wombat to that most active creature, the kangaroo, are all marvelously uniform in their essential structure. Thus no anatomist can be found who desires more than one common root-stock for all these types; and the American opossums have very near relatives among the Australian types.

their far eastern "reserves," grew, only lately (speaking geologically), to a gigantic size; most groups have done so when all things have gone well with them, when they have had peace in their borders and their mouth has been filled with all good things; these gigantic marsupials are all extinct now.

The ganoid fishes of the old red sandstone thus increased and became mighty in the streams and rivers of an ancient world; but the world that then was perished.

After that time the old forefathers of the amphibia thus increased—there were giants also in those days; they existed when the lower types of plants also became gigantic, in the days of the formation of the coal measures.

Later on, aquatic reptiles typified or prefigured the modern mammalian whales; and, still later, terrestrial reptiles grew into monsters, such as fancy never feigned nor fear conceived.

In a yet much later epoch, when, as we have just stated, the marsupials had grown into large and monstrous forms, the armadilloes and sloths also—low Eutherian types—grew into ponderous beasts, whose remains, in many cases so happily recovered, are among the richest treasures of palæontology.

Similar overgrown creatures may have sprung up at one time in the family of the monotremes; but, although the biologist is calling aloud for a revelation of them, there is no voice nor any that regardeth. The biologist has to wait for evidence, and be patient, feeling assured that the earth is rich with hidden treasures of this kind, all of which would witness for him could they be brought to light. It does not disturb his composure when an opponent attempts to bring mere negative evidence wherewith to combat his theory of the earth and its inhabitants; for at any time, any day or hour, the links he is searching for may turn up.

Meantime we may learn much from those sibylline leaves that have become so intensified in their value, because of the destruction of the rest.

From these two living witnesses, the duckbill and the echidna, we learn what a curious reptilian creature a primary mammalian beast may be. These creatures have the great diagnostic, for they have a milk gland, or udder, though no teats; they have also the constant correlate of these glands, namely, a hairy covering. But deep down in their internal construction they are, if compared with the high and noble forms of mammalia, a sort of half reptile; indeed, in some respects more than half. The organs that relate to the maturation of the ovum (egg), and those that pertain to excretion, are quite like those of a bird or reptile. The bones that encircle the chest, the shoulder blades, and collar-bones are of a type far below what is found in the bird, and quite archaic as compared with their counterparts in the common lizard; they are curiously and strikingly like the bones of the shoulder girdle of the great fish-like lizards of the secondary epoch, the ichthyosauri. Their spine, ribs, and breast-bone show a curious mixture of reptilian and mammalian types of structure; their limbs, also, have much primitiveness in them in spite of their perfect specialization for digging purposes. Like birds and tortoises, they have lost their teeth during the ages that have given them so much leisure for special adaptation. The echidna needs none; he is an ant-eater, and for a long while was thought to belong to the same group as the South American ant-eaters, which, however, are low types of the highest group (Eutheria). The duckbill, however, has a sort of excuse for teeth, like the right whale among the higher mammals, and like geese, ducks, swans, and flamingoes in the bird class. The skull, jaws, brain, and organs of the special senses all bear witness to the mixed character—half reptile, half mammal—of these beasts.

He who, knowing these facts, does not draw some remarkable deductions from them must have lost some part of his mental machinery; he who is not excited by our growing knowledge of these ancient types must be as dull as "the fat weed that rots on Lethe wharf."

There is one thing about which biologists, even now, are somewhat doubtful. No low form of vetebrate foreshadows the mammals so much and so well as the *imago stage* of the higher existing amphibia—in plain words, frogs and toads *after their metamorphosis*. Yet the duckbill and the echidna strongly resemble the next higher group above frogs and toads, namely, reptiles; not, indeed, such as those now existent, lizards, snakes, tortoises, etc., but generalized, ancient types. This difficulty has to be looked in the face, and the question asked, Did the lowest mammals arise from, by transformation of, some true reptile—an air-breathing creature from the time of its birth or hatching? I believe not; the confusion and difficulty have arisen from our not having considered that the modern transforming types (the cœcilians, salamandrians and batrachians) must be merely waifs and strays from the fauna of a far distant age. These types, generally small, have large relatives in the coal period, and even they, the labyrinthodonts, may have been the modified descendants of much older transforming fishy creatures. Such supposed types must have begun life with gills for aquatic respiration, and, in their adult state, must have possessed lungs for aerial respiration also; they may or may not have lost their gills as they became adult.

Those who are not familiar with the metamorphosis of the lower forms of vertebrata must trust, not implicitly, to those who are familiar with these phenomena from lifelong observation. He who is acquainted with such matters feels and knows that the existing vertebrata are a sort of united family, after all. The extreme types may call each other "brother"; the lamprey and the man are not very far apart; the head of the group cannot say to the foot, "I have no relationship with thee." When the morphological worker has become familiar with those low fishes, the lamprey and its kindred, passing on to the various higher fishy types with their more and more perfect skeleton and soft organs—then, in studying the structure of the noble, air-breathing sorts, reptiles, birds, and mammals, he is constantly receiving pleasant surprises. He constantly comes across old things in new shapes; he finds structures which were adapted to low types transformed for new uses in creatures that roam over the earth, or take to themselves wings, and, spurning the earth, wing their way through the thin air. He is often to be found muttering over his work the question put by the old preacher, "Is there anything of which it may be said, See, this is new?" Yet these old things may be so transformed during growth that it requires some acuteness to know them under their disguises; also, many things are dropped or suppressed, and others largely developed, while some parts remain permanently in an arrested condition. All this may take place slowly; but during incalculably long secular periods, very wonderful changes may have been brought about by these slow and gentle modifications. Yet changes of this kind, almost insensible, though very potent factors in evolution, are certainly not all that have taken place; some parts must have modified themselves suddenly; but partial, *per saltum* changes, must not be confounded with general metamorphosis.

By metamorphosis we mean such great and sudden *lifetime* changes as we are all familiar with in the insects among non-vertebrate creatures, and in the newt and frog among the vertebrates. Here is certainly something that takes place suddenly—a marvelous leap, so to speak, of an organism into new structural stages, which rapidly fit it for a nobler and higher kind of life than that with which it started. We may call this a catastrophe if we like; we are certainly not prepared with any very satisfying solution of the problem. It is a great mystery—greatest to those who are most initiated. I feel certain that when we have descended to where the three great roads meet—the way of the reptile, the way of the bird, and the way of the mammal—when we get near the great starting point or place whence these three diverged, we shall have to feign to ourselves metamorphic changes as taking place at that very distant point.

The passage from a generalized amphibian into a true reptile does not seem to ask for a very great metamorphic change; but the bird and the mammal, even in their outer covering of feathers and hair, present us with a greater developmental difficulty. The difference between the skin, with its appendages, of a frog or salamander on the one hand and that of a bird or mammal on the other is certainly as great as the difference between the hairy skin of the caterpillar and the scaly covering of the butterfly. Such outgrowths from the skin as feathers and hair are seen for the first time in the bird and mammal respectively; there are no structures comparable to them in any of the types below. Nay, even below the mammals and birds, among the true reptiles, we see modifications of the skin which are quite new to us in the scale of ascent. And these familiar but remarkable outward changes, seen in the three great groups of air-breathing vertebrata, are correlated with equally great internal changes which affect the whole structure of the animal. To me it appears that not even the lowest of these three groups—reptiles, birds, and mammals—arose, without metamorphosis, by gentle, insensible changes from an amphibian type; and I see no reason to suppose that they all three had one common metamorphosing parentage. I should rather be inclined to derive them from the same stratum of life—from the same intensely vital root-stock, but from independent suckers. They would then be quite near enough akin to have very much in common, while the special diverging development in each case may have been sufficient to initiate all those great differences that have appeared during the ages and generations since these air-breathing types arose; yet each group had, possibly, a *multilarval* origin.

The various modes of the development and maturation of the larvæ (tadpoles) of frogs and toads, and the imperfect, hesitating, and irregular metamorphosis of several of the salamandrian types, help us greatly in this dilemma. Nature working, so to speak, after the counsel of her own will, allows a marvelous amount of liberty to her amphibian children, letting them settle their family matters in their own way. And during the chances and changes of amphibian life, now and in the past, there has been a necessity laid upon these lowly tribes to be wise in their generation, and prudently to hide themselves and their offspring from danger in this manner and in that.

Take the case of our common frog, whose eggs and larvæ are a prey to the teeth of a thousand greedy enemies. Those that escape these dangers have barely time to transform and take on aerial and terrestrial life before the streams and the brooks are dried up. In some cases, as in the primeval forests of South America, the eggs are laid and the tadpoles are developed in the midst of the moist herbage at the roots of the trees. In other cases the tadpole never develops more than the merest trace of gills, as in the monstrous toad (*pipa*) of Surinam. In this type the broad, flat back of the female is covered with a multitude of small pockets, each of which, in spawning time, is filled with a single egg about the size of a pea. The egg, being much larger than in the ordinary kinds, has an unusual amount of food yolk in it; and the embryo develops into the larva, and the larva into the perfect toad, in the closed pocket. By the time the young escape from the pouches on the back of the mother, they are as far advanced in development as are the young of the common frog and toad six months after the loss of their tail. In other kinds of South American tailless amphibia the eggs are placed in a large continuous pouch on the back of the mother, a cavity very similar to the abdominal pouch of a kangaroo or opossum.

Again, the tailed amphibia (salamanders and newts), all of which have gills either permanently or for a time, show great variations in the mode of their development. The newt, after hatching, swims about as a gill-bearing larva for some two or three months; but the true salamanders (*Salamandra atra* and *S. maculosa*) are viviparous, and in the latter species the young are retained for a whole year in the oviduct. Nevertheless, the embryo develops gills freely; and if these embryos are artificially born, they breathe by their gills, which they subsequently lose. Certain kinds of the tailed amphibia retain their gills throughout life, although the lungs also are well developed, as in that blind albino the *Proteus* of the subterranean caves of Carniola, and in the American *menobranchus*. The well-known, large, gill-bearing salamander of Mexico—the axolotl—is very apt to undergo transformation when young, and the transformed individual has to be placed in the highest group of the tailed amphibia, while those which do not undergo transformation belong to the lowest.

Directly below these transforming amphibian types, which, normally, have limbs with four or five digits, there is an order of *fishes* which are double breathers (*Dipnoi*), having both lungs and gills, permanently, like the lower, tailed amphibia; the limbs of these fishes do not divide, like those of the amphibia, into fingers and toes. That these forms are very generalized and ancient is quite certain. They are nearly extinct, only one (*Protopterus*) being found in Western Africa, another (*Lepidosiren*) in Louisiana, and a third (*Ceratodus*) in Australia. The teeth of this last kind have been found in nearly the lowest secondary rocks of this country; it was the contemporary of the oldest known marsupial animals.

We are thus led to this important fact, namely, that below these remarkable metamorphosing types, the amphibia, there is a group of fishes, evidently very ancient, of so general a structure as to combine, in their organization, characters that make it difficult to say whether they are more related to cartilaginous fishes, to ganoid fishes, or to amphibia. Now, generalized types such as these double breathing fishes, and types that undergo metamorphosis, are most instructive to the biologist.

The development of these remarkable fishes has not yet been studied. It is very probable that they also undergo metamorphosis.* If this is the case, their larvæ will be found to represent a much simpler and lower kind of vertebrated animal than that of either the newt or the frog.

The facts detailed above will, I think, satisfy any reasonable mind that, although there is nothing in the development of the types that can be called a creative catastrophe, yet remarkable and often sudden changes do take place. If these variations are partial, they lead to the formation of species, genera, and families; but the uprise of such groups as reptiles, birds, and mammals from lower gill-bearing tribes can only be accounted for on the supposition of a complete metamorphosis.

If we knew as much about those ancient amphibia that we suppose were parental to the highest forms as we do about the modern amphibia, tailed and tailless, it is very probable that we should find nothing more to wonder at than we do actually find in the metamorphosis of these familiar types.

It is impossible here to enter into the details of the various stages that are to be found in the embryos of the highest types of the vertebrata; but the embryologist is perfectly satisfied that these are the unused, historical equivalents of stages which were utilized in active life in the ancient types from which the present high vertebrata have arisen.

II.

And now, having thus crept down from rank to rank of the great vertebrate hierarchy, we have found no variation which cannot be accounted for as having been brought about in one or other of two ways, either by slow and gradual modification, as in the case of the various divisions of the mammalia, or by metamorphosis, as, probably, in the rise of reptiles, birds, and mammals from low, generalized, aquatic types. So far, we have been able to give an answer to the first question. We now come to the second question, Did the vertebrata themselves arise suddenly by a creative catastrophe, or did they spring, by metamorphosis, from lower, non-vertebrate types; the forms so metamorphosed subsequently undergoing slow, secular changes?

The attempt to answer this question will be put in as few words as possible. The evidence here in favor of evolution, more or less gradual or sudden, is of precisely the same kind as that with regard to the rise of the higher vertebrata from the lower.

There is a misconception in many minds as to the relation of the vertebrata to the non-vertebrated tribes; the two groups are looked upon as practically the two halves of the animal kingdom. This view is quite erroneous. There are many groups that are the proper zoological equivalents of the vertebrata. The vertebrata are but the highest of the many culminations of the tribes that rise above the protozoa, or first and lowest forms of animal life. Hence, in any attempt to answer this second question, we must keep clear of all other culminations, the various groups of the highly specialized Arthropods, as insects, spiders, lobsters, etc., and also all the various orders of the soft bodied, unjointed shell-fish (*Molluscs*), and, indeed, of many more groups which have become modified in this way and in that, along certain ascending lines.

Now, there is one mysterious little creature, the lancelet (*Amphioxus*), which is neither a vertebrated type nor a worm, but something intermediate between the two; this type yields the first and best light we get upon the difficult subject of the uprise of the vertebrata. The next type below this is the sea-squid (*Ascidian*); of this there are many kinds, species, genera, and families. The ascidians undergo metamorphosis, and are most useful to us in this inquiry while in their larval state. I can only give a very meager account of these two sorts of creatures—the lancelet and the ascidian—and of their relationship to the vertebrata.

First, let it be remembered that these low forms are classified with the vertebrata in one general group—the *Chordata*. They all have a cord of cellular tissue running along the axis of their body—throughout the whole length of the animal in the lancelet, only along the tail in the ascidian larvæ, and from the middle of the skull to the end of the tail in all the vertebrata. This tract of delicate tissue is inclosed in an elastic sheath. In the lancelet and in the vertebrata, the continuous nervous axis lies over this primary skeletal cord, which is more primitive even than the muscular segments into which in these types the body is divided.

Just above the lancelet comes the hag-fish (*Myxine*) with its relative, the large *Bdellostoma* of the Cape region. These also have no vertebræ; they have a strong skull, but their long body, with its numerous fleshy segments or rings, is supported, not by cartilaginous arches or vertebræ, but merely by a huge dorsal cord (the notochord), with its thick, tough, elastic sheath. The lamprey, during its larval life, has the same simple structure, and so have all the vertebrata *for a time*.

The respiratory organs of the fishes just mentioned, and those also of the tadpoles of frogs and toads, enable us to understand the morphology of the aquatic respiratory organs of the true vertebrated types, and to see that they are merely a modification of the huge, vascular, perforated throat of such forms as the lancelet and the ascidian. In these low forms, the large, upper

* Since the above was written, Mr. Caldwell has discovered that the Australian kind—*Ceratodus*—does undergo metamorphosis.

end of the digestive tube is highly vascular, and has a great number of clefts in it, so that water can pass freely through the walls; and thus fresh and fresh currents containing oxygen in solution are perpetually bathing the lining of the throat, with its fine network of capillary blood vessels. The respiratory organs of all gill-bearing vertebrata are but a modification of this simple apparatus, intensely specialized certainly, but fundamentally the same.

These are the most striking harmonies; but embryology is daily bringing to light new evidence of the intimate relationship of the vertebrata to those low, non-vertebrate types which agree with the high forms in having a perforated pharynx for respiration and an axial body cord.

There may have been in the earlier epochs—most probably there were—innumerable low and soft bodied creatures which "died and made no sign"—left no fossil remains. Forms must have existed intermediate, on the one hand, between the sea-squid and the lancelet and, on the other hand, between the lancelet and the low radical forms of the vertebrated types. The morphological distance between a newly hatched frog's tadpole and the adult frog is almost as great as that between the adult lancelet and the newly hatched larva of the lamprey.

Gradually, as biological laboratories and stations increase, and as studies of this kind become more general, so as to make it an opprobrium for any educated man to be entirely ignorant of such matters, the mists that rest upon these great subjects, and the misconceptions that are formed of them, will assuredly disperse. The wish of many, of whom better things might have been expected, is evidently that the shadow on the dial should be brought backward, and not be allowed to take its normal course. There is, however, "no variableness, neither shadow of turning," in the morphological force; it is perpetually clothing itself afresh and afresh with "the things which are seen," itself an emanation from the Great Unseen, the Eternal.

In conclusion, we may rapidly traverse the ground already gone over. Thus we shall see if there is anything that stands in the way of the views here taken as to the origin of the nobler animal forms. If the groups made by zoologists—varieties, races, species, genera, families, etc.—are merely convenient pens into which we may put our cattle according to the nearness or distance of their relation to each other, then it is evident that there are no absolute distinctions between the groups. If, also, the fossil forms—all, as far as they go—suggest the gradual divarication of types from each other during secular periods, according to fixed laws, and if embryology in the revelation of the various stages of development of the embryo gives the same kind of evidence, then it is clear that we are on safe ground, and may confidently draw our deductions.

Now, this is certain, that, whichever great group of gill-less vertebrates we examine—reptiles, birds, or mammals—we may go to the bottom or foundation of that group without ever seeing the necessity for more than a very limited and partial amount of transformation. There, however, we must use our imagination; but if this be bridled and kept well in hand, we shall not be carried away to any region of "science, falsely so-called." Once at the base of these three great groups, we must call in the aid of metamorphosis; yet this need be no greater nor more wonderful than that which we are all familiar with in the development of beetles and of butterflies, of newts and of frogs.

That great change which we call metamorphosis, a most marvelous transformation of an active living creature of a low type into one of a much higher grade, is certainly not quite a soluble problem to us at present. This change, however, is not a rare, momentary, miraculous cataclysm, but a perfectly normal mode, in which the morphological force works in the development of a very large proportion of existing animal forms. It still takes place in several orders of the vertebrata. There is no adult fish, except one or two manifestly degraded types—the hag and the lamprey—that is at all comparable for lowliness to the tadpole of the common frog or toad. Yet this creature, which might have remained in its larval state throughout life, becomes in a few months a much more elevated type than any fish.*

Once at the bottom of the fish class, we are in the neighborhood of forms which, as we have seen, are at an almost immeasurable distance below the vertebrata, and yet give promise of that pattern of structure which characterizes the vertebrata.

When modern biology is as old and as strong as modern astronomy, then those two great problems—the meaning, nature, and causes of metamorphosis and the uprise of the vertebrata from non-vertebrate types—will undoubtedly have received much elucidation. Meantime, there are those who, having put their hands to this plow, will not look back. By them the orderly sequence of organic phenomena is never even imagined as taking place without the introduction of the element of *time*. It has become absolutely impossible for them to imagine that the almost infinite complexity of a high kind of creature—say an ox, a horse, or a man—did at first arrange itself miraculously in an actual moment of time. According to the old notion of creation, atoms must have run into molecules, molecules have become protoplasmic cells, cells become differentiated, and transformed themselves into various tissues, these tissues have become organs of divers kinds, and these organs have been collocated and set to work—with all their harmonious correlations and coadaptations—all this with an utter elimination of the element of time.

This timeless hurly-burly was devoutly attributed to the Eternal.—*Contemporary Review.*

* The tadpoles of some frogs are two or three years before they transform, and may be made to remain much longer in the larval state. I strongly suspect that some individuals among the larvæ of the paradoxical frog (*Pseudis*) do not transform at all. These facts must lead us to see the wide and powerful influence of surroundings, upon both the manner and extent of the development of the individual organism.

THE CARP.

"IT is almost incredible," says the *Deutsche Fischerei-Zeitung*, "that for hundreds of years man should have been engaged in the culture of an animal without knowing on what it feeds; and yet such is the case with respect to the carp. The fish is treated in the methods bequeathed by tradition, and nature is left to do the rest. One after another has said that carp feed on vegetable matter." It appears from a long and carefully carried out series of experiments made by Mr. J. Susta, director of the Wittingau carp fishery, that carp feed chiefly—indeed, he asserts exclusively—on animal food, and that what little vegetable matter it takes into its stomach is taken in by accident when the fish is grubbing after larvæ and insects. "The greenish color of the food found in the carp's stomach has given rise to the idea that it was vegetable matter; but as soon as Mr. Susta made a closer examination, he got rid of the green color arising from the gall, by washing, and found the contents of the stomach to consist almost exclusively of animal remains. Carp full of food were taken from a whole series of ponds and examined, and it was proved that the larvæ of flies, small crustaceans of the *Daphnia* and *Cyclops* genera, as well as the larvæ of *Phryganidæ*, form the principal food of carp."

"It has been calculated that in one year a female *Cyclops* would become the progenitor of more than four billions of young." The various species of the genus *Cyclops* abound in inland waters all over the world.—*Fishing Gazette, April* 4, 1885.

THE CULTIVATION OF TIMBER.

WHILE there has been a good deal said of late about the necessity of taking greater care of such timber land, overgrown with the original forests, as the country yet possesses, we think that far too little attention has been given to the starting and caring for of a second growth on lands already denuded by the lumberman and the tanner. In the care of most of the land so cleaned within the last fifty years in New York State, Connecticut, Massachusetts, Vermont, and New Hampshire, choice varieties of timber would probably furnish a more remunerative yield in the end than any other use to which the land could be put; for although it could not be made to pay immediately, as with ordinary agricultural products, the land itself has not been of a character to pay for ordinary farming purposes. Speaking of this matter, *Outing* truly remarks that "wood of some kind is the natural product of the soil; for if left to itself, it rapidly grows up, it may be, to chestnut, oak, hickory, or other valuable wood; or, it may be, to white birch, alder, poison sumac, or something else equally worthless. There is little doubt, that any land on which the latter kinds grow so spontaneously would, with a little care, produce some of the valuable varieties; for instance, land that seems too poor to bear anything but white birch might be induced instead to bear white pine, especially as this variety flourishes in very poor soil. In like manner, the swamps, which now abound in alder and sumac, might be made to bear white cedar, or even pine, as is attested by the various denuded pine and cedar swamps in the different parts of the State. One consideration worthy to be taken into account, when we contemplate making plantations of timber, is, that the soil will not be exhausted by its growth, as it is by many other crops. It is well known that trees derive a great part of their substance from the atmosphere and from water, the decaying leaves seeming to supply more fertilizing material to the soil than the roots extract from it; for who is not aware that our forest lands, when cleared, make excellent grass and grain lands until their fertility is exhausted by a process less in harmony with the operations of nature? But will it pay to cultivate timber? It might be questionable to put high priced land to such use, but we have abundance of rocky lands, and some not so rocky, which, on account of its distance from market, or other causes, is not highly valued for other purposes."

THE HARVEST OF THE SEA.

IF Mulhall's statistics are reliable, there are not far short of 150,000 vessels engaged in Europe and North America in fishing. Between 600,000 and 700,000 men are employed in this industry, and the total annual product of fish is not far short of 1,500,000 tons. Few people realize the full meaning of these latter figures. A ton of fish is equal in weight to about 28 sheep, and hence, if Mulhall's estimate is approximately correct, a year's fish supply for ten European countries, included in this estimate, and the United States and Canada, might be represented by 42,000,000 sheep. Of this amount the United Kingdom, Canada, Russia, and the United States, alone, aggregate 1,000,000 tons, equivalent to 28,000,000 sheep.

It has been truly said that we talk in a metaphor of the "harvest of the sea," but we have only lately been able to realize all that the metaphor means. The Fisheries Exhibition in London in 1883 did a great deal to encourage the study of marine biology, and it is with no small degree of satisfaction that we are able to say that in this much-needed work the United States ranks second to no other country. On the other hand, Great Britain, whose fisheries are of vital importance to her for food, has done little, and cannot yet boast a laboratory on the sea shore. Indeed, Professor Lankester, an eminent authority on marine biology, declares the British fishing industries still barbaric. The produce of the sea is recklessly seized, regardless of the consequences of the method, the time, or the extent of depredations.

According to an English authority, the old proverb that "there are as good fish in the sea as ever came out of it" no longer holds good. The harvests of the sea in the future, like the harvests on land, will need cultivating. It was shown, not long ago, that in eight months 28 boats engaged in the haddock fishery at Eyemouth, England, used 620 tons of mussels—about 47,000,000 mussels—in the capture of haddock. Yet Professor Lankester says that no pains are taken in England to cultivate or preserve the mussel, and knowledge of its reproduction and growth is still incomplete, as it is of other bait. Soles are every year becoming scarcer, and oysters are becoming more difficult to obtain. At present, says this same authority, absolutely nothing is known as to the spawning of the sole; and the male fish is not even recognized. The reason for oysters being scarce is not known, nor how to make them abundant.

There are many economists in England who maintain that the haphazard and improvident methods of fishing are exhausting the fish supply of that country as surely as the mining is exhausting the supply of coal. The supply of many kinds of fish is rapidly diminishing, and the only way to check the waste is by systematic study of the conditions which regulate the supply. It is undoubtedly true that "the world could not be fed if men sought their food on land with as little forethought and system as fishermen cast their nets into the sea." To what extent these facts, which are causing desiderable discussion in England, apply to the United States we are not prepared to say. The excellent work for many years of our Fish Commission exonerates our Government from the charge of total neglect of this important industry. Several States have fish commissioners, and, together with the National Government, have accomplished much useful work in the artificial breeding of codfish, shad, oysters, etc. Indeed, the production of fish all over the United States has undoubtedly been largely increased by scientific research. It is not improbable that the annual fish product at present in the United States is equivalent to from 4,500,000 to 5,000,000 sheep. With the increasing demand for food, and with abundant evidence from other countries of the result of neglect, we should rather increase than relax our efforts to understand more about the food, habits, spawning, and propagation of our fish, in rivers, lakes, and the sea, in order that the harvest may not grow less as the demand becomes more urgent.—*Philadelphia Press.*

A NEW dressing or size for wool and silk consists in 50 pounds potato starch, which is finely distributed in the necessary quantity of water and boiled to a paste; then 50 pounds magnesium chloride are slowly stirred in, and finally one-half pound hydrochloric acid is added, and after boiling for one hour longer the mixture is accurately neutralized with lime water. By continuing the boil for another hour, a gelatinous liquid is obtained, which, besides being very cheap, when used for dressing or sizing woolen or silk yarns or tissues, gives them a delicate luster and a good touch, which remains even after washing with water.

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TABLE OF CONTENTS.
